Problem-Solving with Nim

No. A-257
Instructional Computing Courseware
for Apple® II Series Computers

for the love of learning

mecc

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Instructional Computing Courseware
for Apple® II Series Computers

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This manual is compatible

with

the ***Problem-Solving with Nim*** disk

Version 1.x

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Problem-solving with nim [computer file]. — Version 1.0.

1 computer disk ; 3 1/2 in. + 1 manual.
System requirements: Apple II series computers; 128K RAM; ProDOS; BASIC; 1 disk drive; monochrome or color monitor.
Title from title screen.
Edition statement from disk label.
Copy-protected.
Audience: Grades 3-8.
Issued also on 5 1/4 in. computer disk.
Summary: A program, based on the ancient game of Nim, that helps students work on their problem-solving strategies and logical-thinking skills. Variations on the game of Nim—Fish Nim, Calculator Nim, Space Nim, and Moonlight Nim—serve both as a problem-solving activity and a way to develop some of the basic concepts of divisibility, remainders, and modular arithmetic.
"A-257"— Disk label.
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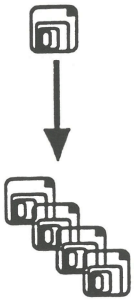	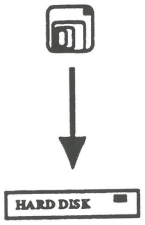	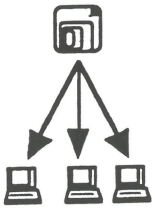	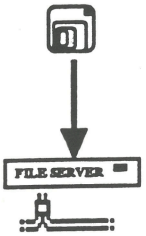
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	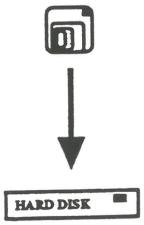	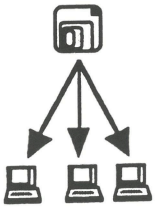	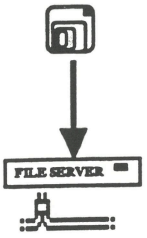
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	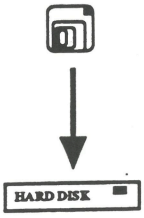	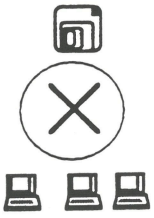	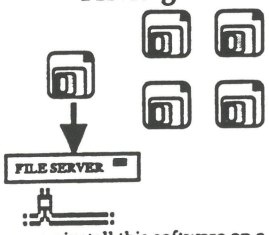
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INTRODUCTION

Through the centuries, mathematical puzzles have challenged people of all ages. In general, there are two different types of puzzles: one requires numerical computation to solve the puzzle; the other requires the manipulation of objects to find the solution. One of the oldest and most popular of the latter type is the game of Nim.

In Nim, a certain number of objects are arranged in some discernible manner. Each player takes turns removing up to a specified number of objects, and the player taking the last object either wins or loses, depending on how winning is defined. (Nim is commonly played either way.) The name Nim, incidentally, was given to the game at the turn of the century by Harvard professor Charles Bouton, who studied the strategy of the game. The word "nim" is a verb that means "to pilfer or steal."

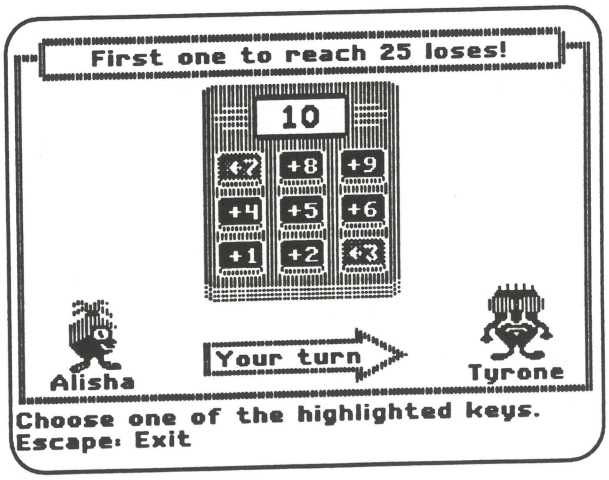
The exact origin of Nim is not clear, but many speculate that it may have originated in China. Others have suggested that it may be a derivative of the Mancala games that have been played for centuries in Africa. These games involve placing pebbles in pits and removing the pebbles in various ways. Regardless of the origin, Nim has remained a popular game through the centuries.

Perhaps the most popular form of Nim involves arranging objects in rows and allowing players to remove as many objects on their turn as they want, provided that the objects are all from the same row. Finding a general solution for this version of Nim has intrigued many people; in fact, this version is often used in computer science courses to study binary systems and the concept of parity. Machines have even been designed and built to play this version of Nim. In 1940, Edward Condon invented the "Nimatron," a one-ton machine that could play games with four rows of up to seven counters. It was displayed in the Westinghouse Building at the New York World's Fair and won nearly all the games it played! Many improved versions of the Nimatron have since appeared and have been very popular.

Part of Nim's intrigue must certainly be due to its simplicity: it is a game that can be easily learned in only a few seconds. Despite its simplicity, however, it can take days to master. While many players will discover a winning strategy for a certain set of conditions and be able to win consistently, the challenge is to learn to apply that same strategy to slightly different situations when they occur. Discovering a general solution, rather than memorizing a set of winning moves, provides the most interest and intrique. So far, winning strategies have been found and documented for the programs **Fish Nim** and **Space Nim** as well as for the version of **Calculator Nim** using all the keys. On the other hand, little is known about the other versions of **Calculator Nim**. Likewise, there is currently no known general solution to winning the **Moonlight Nim** game.

Problem-Solving with Nim provides you with an engaging activity to promote logical reasoning. Students will be both challenged and frustrated as they play the various games. Encourage students to discuss strategies with each other and look for general solutions.

THE PRODUCT AT A GLANCE



Title: ***Problem-Solving with Nim***

Grades: 3-8

Subject Area: Mathematics

Topic: Problem-solving

Hardware: Apple II series computer with at least 128K of memory and one disk drive

Programs Included: **Fish Nim, Space Nim, Calculator Nim,** and **Moonlight Nim**

Management Options: Individual games can be turned off or settings modified; students can be allowed to also modify game settings

Classroom Use: Individual students, pairs of students, or small groups

Description: Students are presented with four variations of Nim, an ancient game of logic and reasoning. Games can be modified for variety and to test the validity of winning strategies.

Learning Objectives:

- to engage students in challenging problem-solving situations
- to provide an application of various math concepts
- to practice using visual reasoning
- to develop problem-solving strategies

MANAGEMENT OPTIONS

Problem-Solving with Nim contains four management options designed to give the teacher some control in the design and availability of the different games. To access the Management Options, press Control-A (hold down the Control Key and then press the letter A) while viewing the main menu (Figure 1). The Management Options menu will then appear (Figure 2).

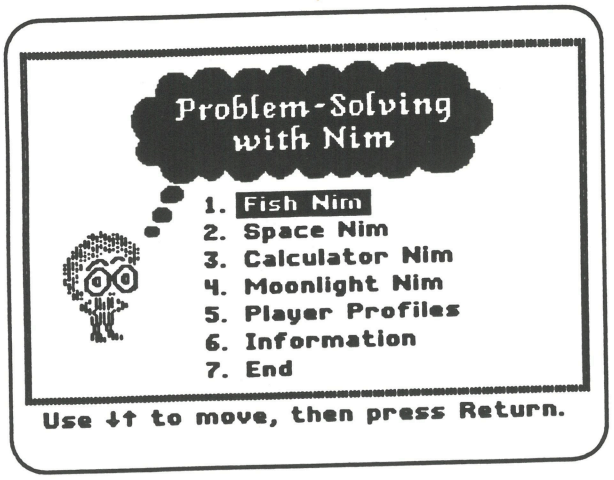


Figure 1

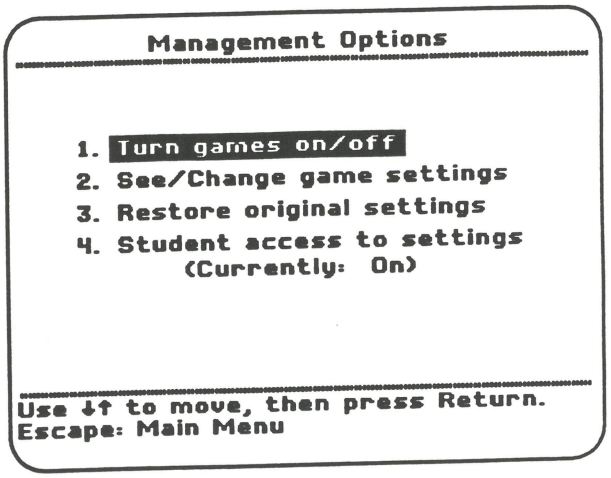


Figure 2

Option 1: Turn games on/off

This option allows you to turn off any of the games that you may feel are not appropriate for use by your students. Simply move the cursor to the appropriate game and press Return to toggle the on/off message (Figure 3). When turned off, the name(s) of the game(s) will not appear on the main menu (Figure 4).

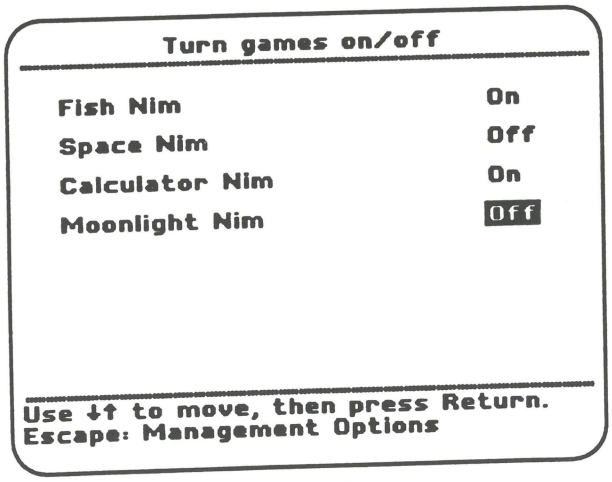


Figure 3

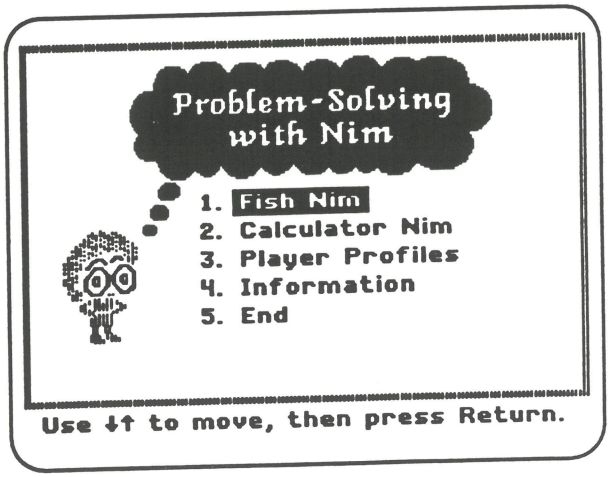


Figure 4

Option 2: See/Change game settings

The disk was originally released with predetermined settings for each of the four games. These settings are the ones that will appear each time a new game is accessed. You may change these settings, however, by using this option (Figure 5). Changes that you make for any of the games will be then be saved and become the new default settings for games on this disk (Figure 6).

For more information on making the actual changes, consult the "Use in an Instructional Setting" section for each game.

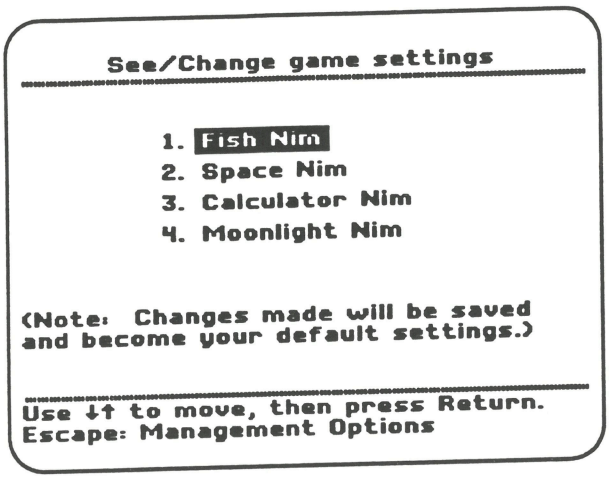

See/Change game settings
1. Fish Nim
2. Space Nim
3. Calculator Nim
4. Moonlight Nim
(Note: Changes made will be saved and become your default settings.)
Use ↓↑ to move, then press Return.
Escape: Management Options

Figure 5

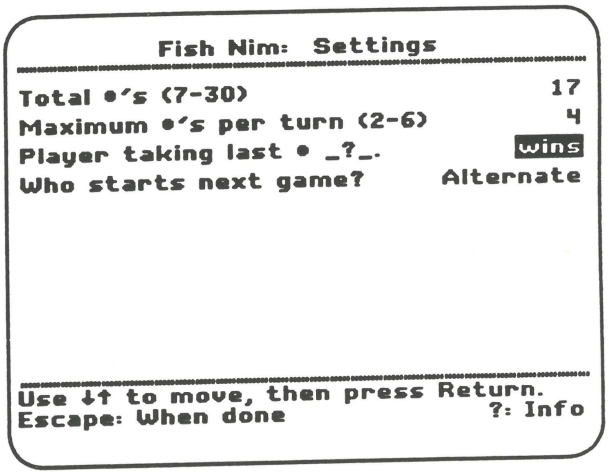

Fish Nim: Settings
Total •'s (7-30) 17
Maximum •'s per turn (2-6) 4
Player taking last • _?_. wins
Who starts next game? Alternate
Use ↓↑ to move, then press Return.
Escape: When done ?: Info

Figure 6

Option 3: Restore original settings

This option is provided to restore the original settings that were on this disk when released (Figure 7). The original default settings for all four games have the players alternate starting each game and allow them to change the game settings. Other settings include:

Fish Nim – Start with eleven •'s; take up to three •'s per turn; the player taking the last • loses.

Space Nim – Start with three rows (3/4/5); the player taking the last asteroid loses.

Calculator Nim – Start at zero; addition; allow use of all keys; the first player to reach 25 loses.

Moonlight Nim – Start with a 3x5 grid; turn off up to four adjacent lights per turn; the player turning off the last light loses.

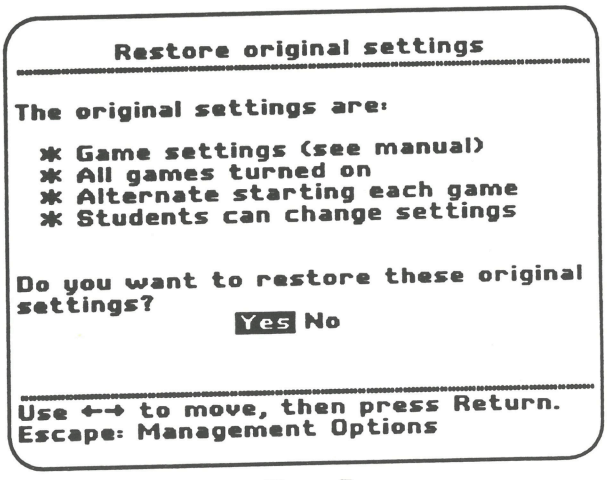

Restore original settings
The original settings are:
* Game settings (see manual)
* All games turned on
* Alternate starting each game
* Students can change settings
Do you want to restore these original settings?
Yes No
Use ←→ to move, then press Return.
Escape: Management Options

Figure 7

Option 4: Student access to settings

Using Option 2, "See/Change game settings," you could change the settings for any of the games to meet your teaching needs. This same choice can also be given to the students (Figure 8). When this option is on, students will be allowed to change the game settings before the start of each game (Figure 9) and also at its conclusion. Allowing students the option to change settings lets them test strategies under different sets of conditions. Changes made by students, however, are not saved on the disk and are lost once students return to the main menu.

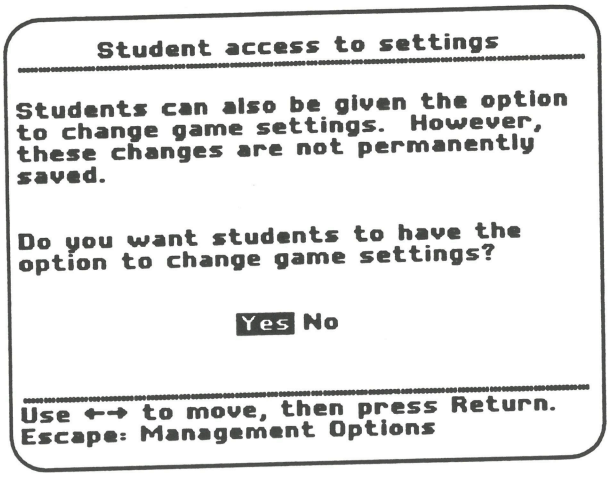

Student access to settings
Students can also be given the option to change game settings. However, these changes are not permanently saved.
Do you want students to have the option to change game settings?
Yes No
Use ←→ to move, then press Return.
Escape: Management Options

Figure 8

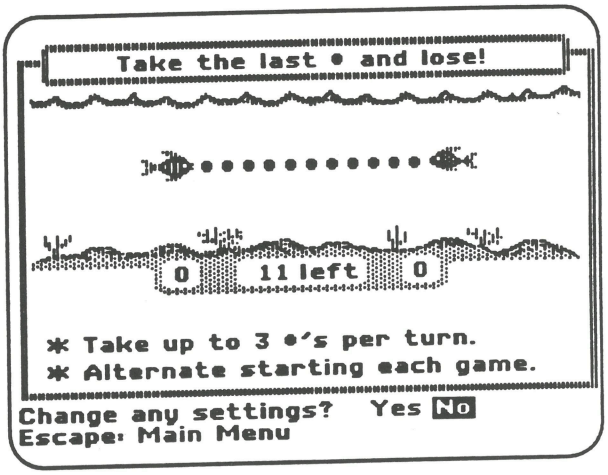
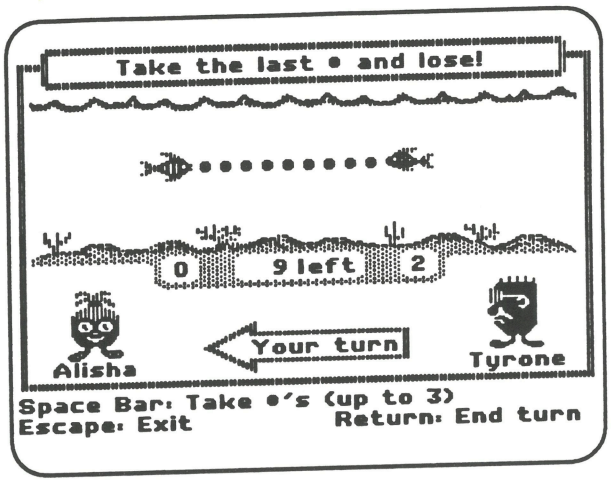


Figure 9

THE PROGRAM AT A GLANCE



Program Type: Problem-solving game

Classroom Use: Individual student (plays against a computer opponent), two students (play against each other), or small group (cooperative learning)

Description: **Fish Nim** provides students with a simple game, requiring them to think logically in order to be successful. Players take turns removing dots (high-protein fish food) by directing a fish to eat the dot. Players can take any number of dots up to the specified limit on their turn (see the instruction line at the bottom of the screen above). Depending on how the win rule is set, the player forced to take the last dot is either the loser or the winner. In the example above, each player can take up to three dots per turn and the player taking the last dot is the loser.

Objectives:

- to provide students with an engaging problem-solving activity
- to provide an application using division and remainders
- to practice using visual reasoning
- to develop problem-solving strategies

USE IN AN INSTRUCTIONAL SETTING

Background Information

Fish Nim is one of the easiest versions of Nim to play, yet it can still provide students with a challenge. It can be played using pencils, coins, or any small objects; the rules are simple; and it takes very little time to play.

Rules for **Fish Nim**

1. The player starting the first game is randomly selected.
2. There are a total of T dots at the start of the game (T can be set between 7 and 30).
3. A player can take up to N dots on his or her turn (N can be set between 2 and 6). At least one dot must be taken on each turn.
4. The loser (or winner, if set this way) is the player taking the last dot.
5. According to the settings, the player starting the next game is randomly selected, is alternated, or is the winner or the loser of the last game.

Strategy

There is a general strategy that can help one win when playing **Fish Nim**. *This strategy is presented here for reference purposes only!* Students will not gain much from being taught the strategy and then being asked to apply it. This will take away the thrill of discovery and all the problem-solving that must go into developing a strategy. It may even be advisable for teachers to skip over these next few paragraphs and also to go through the process of discovering a strategy!

There are four important factors to consider when planning a strategy. They are:

1. How many total dots (T) remain?
2. What is the most dots (N) that you can take on each turn?
3. Is the player taking the last dot the winner or the loser ?
4. Who starts the game?

The total number of dots taken in a round can be controlled by one of the players. A *controlled round* consists of two turns, one by each player, in which the total number of dots taken is one more than the maximum number of dots that can be taken on a turn. For example, if each player is allowed to take up to three dots on his or her turn, a *controlled round* is a pair of moves in which a total of four dots are taken by the players. Furthermore, the second player in the round is the one controlling the outcome to ensure that four dots are taken. If the first player takes one dot, then the second player takes three dots. If the first player takes two dots, then the second player takes two dots. If the first player takes three dots, then the second player takes one dot. These are all the possible combinations in which the second player has controlled the round by taking enough dots to make a total of four dots.

USE IN AN INSTRUCTIONAL SETTING (continued)

A game starts with a total of T dots to be taken and you can take up to N dots on your turn. The first step in developing the best strategy for a game is to note how many controlled rounds are possible in the game. Divide the total number of dots (T) by the number of dots in a controlled round (N+1). The quotient is not important. Take note of the remainder. This number will determine the best strategy for starting the game. Incidentally, it is usually to your advantage to start so that you can always be in control. As you will soon see, however, there are two situations when that is not the case.

Let's go back to the example in which there was a total of eleven dots (T=11) and one could take up to three dots per turn (N=3). Since 11 = 2(4) + 3, there are two controlled rounds in this game, with three dots remaining. Planning ahead for these three remaining dots is an important part of the strategy. You must now pay attention to whether you want to take the last dot in order to win and whether you will be starting the game. In this particular case, it is to your advantage to start the game. If you want to take the last dot in order to win, start the game by taking the three dots composing the remainder and then control the remaining two rounds by taking the appropriate number of dots to make a total of four per round. If you do not want to take the last dot, start the game by taking only two of the three dots composing the remainder, leaving the other for your opponent to take as the last dot. Then control the two rounds by taking the appropriate number of dots to make a total of four per round.

This strategy can be summarized by showing a table based on the different remainders that one could have when the total number of dots (T) changes but the number of dots that can be taken per turn stays the same (three). As you look through the table, notice the relationship between the number of dots left and the corresponding strategy.

Table for games in which up to 3 dots can be taken per turn

Total dots (T)	Controlled moves (4) possible	Dots left	Strategy if you *want* the last dot	Strategy if you *don't want* the last dot
7	1	3	Start . . . take 3 . . . control.	Start . . . take 2 . . . control.
8	2	0	Don't start . . . control.	Start . . . take 3 . . . control.
9	2	1	Start . . . take 1 . . . control.	Don't start . . . control.
10	2	2	Start . . . take 2 . . . control.	Start . . . take 1 . . . control.
11	2	3	Start . . . take 3 . . . control.	Start . . . take 2 . . . control.
12	3	0	Don't start . . . control.	Start . . . take 3 . . . control.
13	3	1	Start . . . take 1 . . . control.	Don't start . . . control.
14	3	2	Start . . . take 2 . . . control.	Start . . . take 1 . . . control.
15	3	3	Start . . . take 3 . . . control.	Start . . . take 2 . . . control.
:	:	:	:	:
:	:	:	:	:
30	7	2	Start . . . take 2 . . . control.	Start . . . take 1 . . . control.

USE IN AN INSTRUCTIONAL SETTING (continued)

Here is another way to visualize the strategy. Look at the line from the table with the total number of dots equal to 11. There are two controlled rounds possible and a remainder of three dots to deal with. In the illustration below, the 0's represent dots that you have taken and the o's represent dots taken by your opponent. A controlled round can be represented as [oøø0], where the first dot was taken by your opponent (o) and the middle two dots (ø) taken by either player. However, you (0) have definitely taken the last dot in the group.

Best strategy to use if you want to take the last dot . . .

1. Start by taking three dots.
2. Control the last two rounds.
3. You win because you took the last dot.

000
[oøø0] [oøø0]

Best strategy to use if you don't want to take the last dot . . .

1. Start by taking two dots.
2. Control the next two rounds.
3. You win because your opponent took the last dot.

00
[oøø0] [oøø0]
o

To generalize about the above strategy, *you can win any game that you can control.* If you should lose track of your strategy during the middle of a game, just divide the number of dots left by (N+1), check the remainder, and continue using the appropriate strategy for that remainder.

Preparation

Before using this game with your students, you should first familiarize yourself with the rules and play a few games against Spike, the resident Nim expert. Then examine the range of settings available and, if necessary, modify the settings to meet your needs or the ability level of your students. See pages 3-5 for information on how to change these settings on the disk. Here are a few things to consider while deciding what the appropriate settings might be for your students:

Total number of dots (7-30) – Increasing the number of dots (pieces of fish food) does not necessarily make the game more difficult, but using a small number of dots can promote visual reasoning as students try to find a strategy or to work the problem backwards. The original setting on the disk calls for eleven dots.

Maximum number of dots that can be taken per turn (2-6) – This value can be adjusted in order to keep the total number of moves in a game reasonable. For example, if you had thirty dots and allowed only up to two dots per turn, it would take at least fifteen turns to complete a game.

Player taking the last dot wins or loses? – Over the centuries, Nim has commonly been played both ways.

USE IN AN INSTRUCTIONAL SETTING (continued)

Who starts the next game? – Alternating starters or randomly picking the starter is certainly a fair way to approach this setting. Starting the game is usually the key to winning, once you have discovered a strategy. The exceptions to this are noted in the previous section. Therefore, allowing the loser to start a game could provide students who may not yet have discovered the strategy with more of an opportunity to succeed.

The game can be played by individual students competitively or by small groups of students working cooperatively against one of the computer opponents. Three opponents are provided: Spike, Ace, and Biff. Spike uses a winning strategy at all times and will win all games started with a winning advantage and any game in which a player makes an error in reasoning. Ace starts each game in a somewhat random fashion but eventually uses sound strategy. Biff plays in a very haphazard fashion and is easy to defeat. You may want to suggest to your students that they start playing against Biff, then try Ace, and finally try Spike. The game can also be played competitively between two students.

Before using **Fish Nim**, you may want to consider introducing students to the game, using actual objects such as small pieces of paper or checkers. Pair up students, give them a set of objects, and explain the rules. Do not use the same number of objects as you plan to use in **Fish Nim** and allow them to take up to a number of objects on each turn that is different than the number used in **Fish Nim**. Also, let them decide on their own who should start each game. After a while, many of the students will discover a strategy that seems to allow them to win quite often. They should also discover that it is an important factor who starts the game. When the game is played with different settings, it will be readily apparent if their strategy is a good one. Often students develop a winning strategy by memorizing a winning combination of moves, but this strategy does not transfer to new situations. Therefore, encourage students to chart the moves made by both players during a game and to look for patterns.

Minimal time is required to play a single game of **Fish Nim**, so you may wish to set up sessions in which students play several rounds and determine a winner by who wins the most rounds. If time permits, a **Fish Nim** tournament could be organized.

USE IN AN INSTRUCTIONAL SETTING (continued)

Using the Program

To play **Fish Nim**, select it from the main menu (Figure 1). If this is the first time your students have used this package, you may first want to have them read through the Player Profiles to get an indication of the abilities of the three computer players (Figure 2).

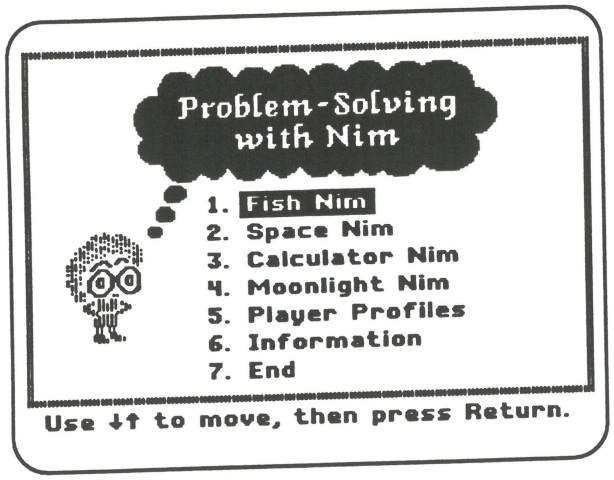


Figure 1

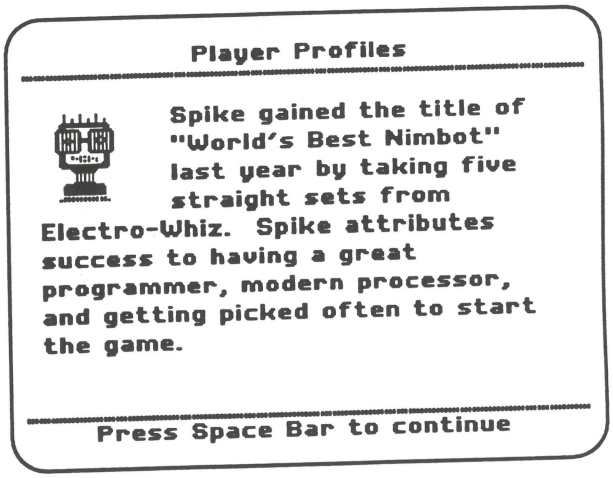

Player Profiles
Spike gained the title of "World's Best Nimbot" last year by taking five straight sets from Electro-Whiz. Spike attributes success to having a great programmer, modern processor, and getting picked often to start the game.
Press Space Bar to continue

Figure 2

The first screen summarizes the rules of the game based on the current settings. If players are allowed to change settings, that option will also be displayed (Figure 3). If players are not allowed to change settings, only a "Press Space Bar to continue" message will be displayed. If a change in settings is selected, the screen shown in Figure 4 is seen and changes can now be made. Student changes are temporary and are not saved on the disk; they will be lost after students exit from the game and return to the main menu.

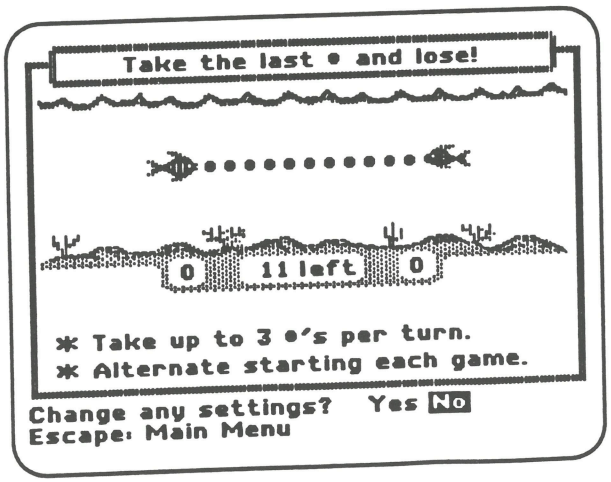


Figure 3

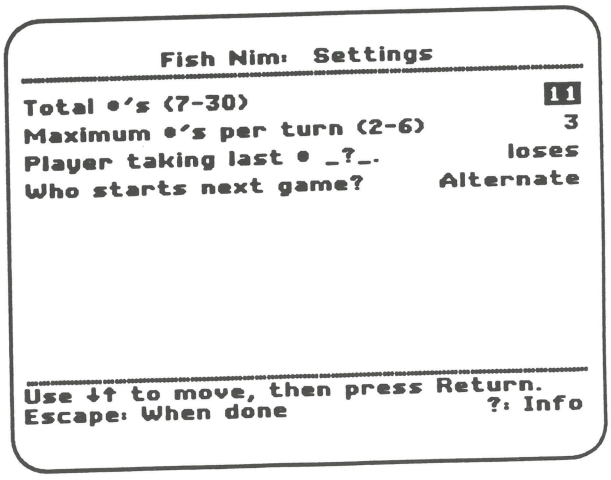

Fish Nim: Settings
Total •'s (7-30) 11
Maximum •'s per turn (2-6) 3
Player taking last • _?_. loses
Who starts next game? Alternate
Use ↓↑ to move, then press Return.
Escape: When done ?: Info

Figure 4

USE IN AN INSTRUCTIONAL SETTING (continued)

Before starting a new game, the first player is asked to enter his or her first name and choose a character to represent him or her during the game (Figure 5). The player is then asked to select an opponent (Figure 6). Descriptions of the style of play for the computer players (Spike, Ace, and Biff) are available by selecting Player Profiles on the main menu.

Figure 5

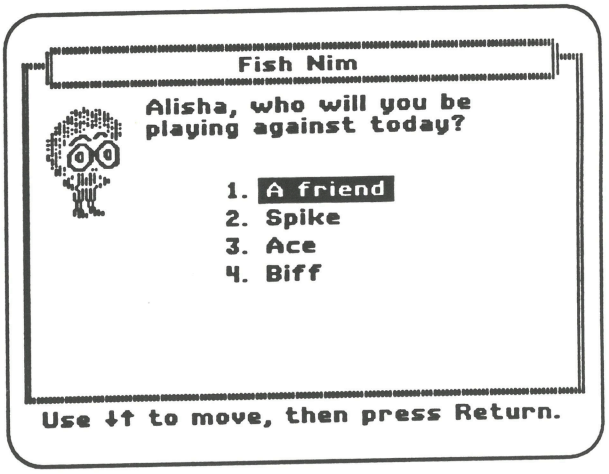


Figure 6

The game hostess, Ima Thinker, will randomly decide who starts the first game (Figure 7). From then on, the player starting each game will be determined according to the game settings. The main game screen will then appear. Instructions for all possible options at this point are shown at the bottom of the screen (Figure 8). Each player can take up to the specified number of dots on his or her turn by pressing the Space Bar an appropriate number of times. If a player wants to end a turn before taking the maximum number of dots allowed, the Return Key should be pressed. At least one dot must be taken on a turn.

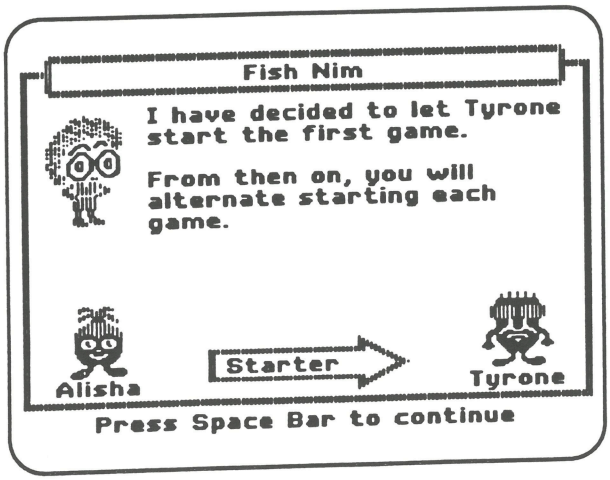

Fish Nim
I have decided to let Tyrone start the first game.
From then on, you will alternate starting each game.
Alisha
Starter
Tyrone
Press Space Bar to continue

Figure 7

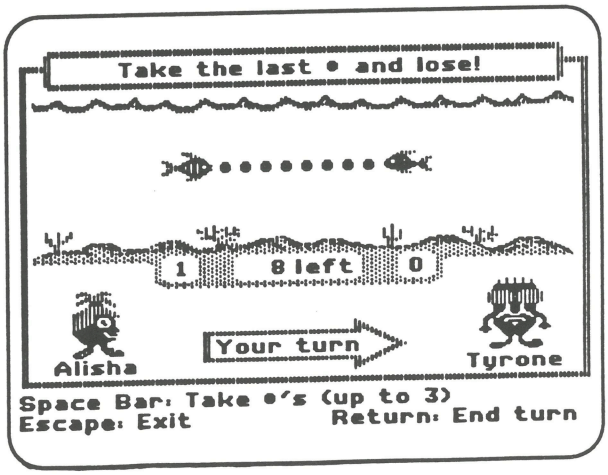


Figure 8

USE IN AN INSTRUCTIONAL SETTING (continued)

After the last dot is taken, the winner is announced (Figure 9). Remember, depending on the game settings, a player could win or lose by taking the last dot. The current setting is reflected in the message printed at the top of the screen. Following each round, a summary screen that gives the current number of wins for each player is shown (Figure 10). At this point, a player can choose to play again, change players or characters, or quit and return to the main menu. If allowed, game settings can also be changed at this point. See pages 9-10 for more information about this option.

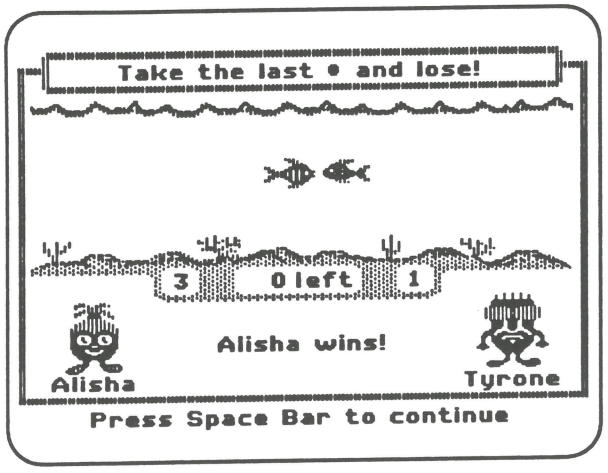


Figure 9

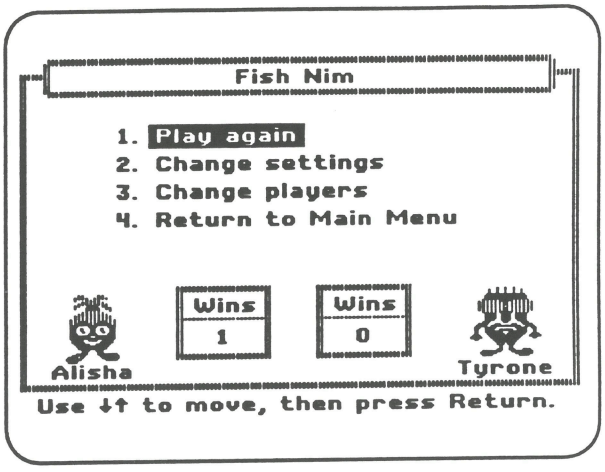
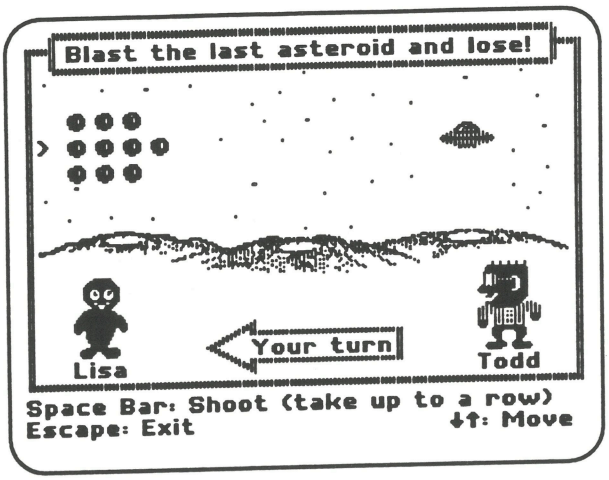


Figure 10

THE PROGRAM AT A GLANCE



Program Type: Problem-solving game

Classroom Use: Individual student (plays against a computer opponent), two students (play against each other), or small group (cooperative learning)

Description: **Space Nim** is one of the most popular versions of Nim. The rules are simple. There are two to five rows of asteroids, each row having up to nine asteroids. Players take turns destroying asteroids. One asteroid or more can be blasted on a turn, provided that each comes from the same row. Depending on the game settings, the player blasting the last asteroid is either the winner or loser. The most popular version of **Space Nim** is played with three rows of asteroids containing three, four, and five asteroids.

Objectives:

- to provide students with an engaging problem-solving activity
- to provide an application using binary concepts
- to practice using visual reasoning
- to develop problem-solving strategies

USE IN AN INSTRUCTIONAL SETTING

Background Information

Of all the Nim games, this version has received the most attention. The game is simple and starts with two or more piles of objects. Players may take any number of objects from any pile as long as the objects all come from the same pile. Players soon begin to recognize that leaving certain combinations of objects make winning certain. In 1901, Charles Bouton, a professor of mathematics at Harvard University, was the first to produce a general strategy for this game. His strategy was surprisingly simple and allowed one to play a perfect game by applying some binary principles regardless of how many piles and total objects were involved.

Because the solution to this game is based on binary principles, it is possible to build machines using switches and relays to play a "perfect" game. (See the discussion of the "Nimatron" on page 1.)

Nim is also one of the most frequently programmed computer games for two players. Many computer programming courses use this game for students to study such topics as computer logic, binary numbers, and parity.

Rules for **Space Nim**

1. The player starting the first game is randomly selected.
2. The game begins with two, three, four, or five rows of asteroids. Each row can contain up to nine asteroids.
3. Players can blast any number of asteroids on their turns, provided that all asteroids are taken from the same row. At least one asteroid must be blasted on each turn.
4. The loser (or winner, if set this way) is the player blasting the last asteroid.
5. According to the settings, the player starting the next game is randomly selected, is alternated, or is the winner or loser of the last game.

Strategy

The general strategy for **Space Nim** requires that the player has some understanding of binary numbers or is able to use a chart to convert decimal numbers to binary numbers. The binary system of numbers has only two digits (0 and 1) and uses powers of 2 for place value. For older students, this game may provide the "teachable moment" for introducing them to the binary system.

When Bouton published his solution to the game, he described the current conditions as either "safe" or "unsafe," based on the number of objects in each row. A "safe" condition exists when there is a specific combination of objects left that will eventually allow a player to win if no mistakes are made. Any other combination is considered "unsafe." Of course, learning how to evaluate the current conditions is the key to learning how to apply the general strategy.

USE IN AN INSTRUCTIONAL SETTING (continued)

Before discussing the general strategy, consider the following observation made by many beginning players: *"If you can get down to two rows of objects with the same number of objects in each row, you can easily win."* Thus, keeping the number of objects the same in each of two rows is considered a "safe" condition, as are a few other familiar combinations, such as the 1-2-3 combination (where there are one, two, and three objects, respectively, left in three different rows) and the 1-4-5 combination. Many players try to remember these various combinations that seem "safe" and try to achieve these conditions in order to win; however, a strategy does exist that makes it possible to check *any setup* for being "safe" or "unsafe."

To determine whether the current setup is "safe" or "unsafe," write down the number of objects remaining in each row. Convert each of these numbers to its binary equivalent. Then add up the 0's and 1's in each column. If the sum in every column is even (or zero), this setup is considered "safe." If any column has a sum that is odd, the setup is considered "unsafe." In order to win, you make each move so that the setup left is "safe."

Consider the popular 3-4-5 game of Nim (three rows containing three, four, and five objects). Start by writing down the number of objects in each row and convert each of these numbers into its binary equivalent. Next, add the digits in each column of the binary values. Because the sum of the digits in the middle column is an odd number, the current setup is considered "unsafe." In order to be "safe," all the digits must be even or zero.

Current Setup	Number of Objects	Binary Equivalent
000	3	011
0000	4	100
00000	5	101
		212 <— "unsafe"

Any setup considered "unsafe" can always be made "safe" by removing the right number of objects from the right row. In the chart above, notice that two of the columns have sums that are even. The player must now determine how to remove some objects in order to make the sum of the middle column either even or equal to zero. By removing the middle "1" in the binary number "011" would certainly allow us to attain a "safe" status. Some understanding of place value in the binary system is, of course, helpful. The column farthest to the right represents the 1's place, the middle column is the 2's place, and the left column is the 4's place. Therefore, the player wants to remove one group of two from the top row containing three objects. This move will produce the following setup:

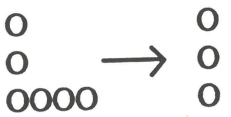
Current Setup	Number of Objects	Binary Equivalent
0	1	001
0000	4	100
00000	5	101
		202 <—"safe"

USE IN AN INSTRUCTIONAL SETTING (continued)

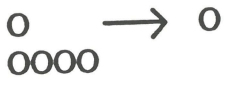
Bouton made an important observation about the conditions as play progresses during the game. He noted that every "unsafe" setup could *always* be made "safe" by making an *appropriate* move and every "safe" setup is *always* made "unsafe" by making *any* move. Therefore, if you leave the safe 1-4-5 combination for your opponents, they will make the setup "unsafe" regardless of what they take. You can then convert the "unsafe" setup left for you by making the appropriate move. The game continues in this manner until the end.

This leads us to a very important question: "Is there any advantage to starting the game?" The answer depends on what the initial game setup looks like. If the game starts with an "unsafe" setup, it is advantageous to start since you can make the setup "safe" by making the appropriate move. If the game starts with a "safe" setup, you do not want to start. If you do have to start in this situation, make a random move and hope that your opponent makes a mistake!

Another important consideration is based on whether you want to take the last object in order to win. If you want to take the last object in order to win, always make the setup "safe." If, however, the rules state that the player taking the last object loses, the strategy must be modified during the final few moves. There are three situations which the strategy changes to leaving an "unsafe" setup in order to win. These are:



1. **Setup of 1-1-2 (or more)** – This setup has two rows that contain exactly one object each and a third row with two or more objects. This is an "unsafe" setup and, in order to win, it must be left "unsafe" by removing all but one of the objects from the row with two or more objects. The remaining setup of 1-1-1 will guarantee that the opponent will have to take the last object.



2. **Setup of 1-2 (or more)** – This setup has two rows that contain objects. One row has only one object and the other row has two or more objects. This is an "unsafe" setup and, in order to win, you must take the entire row containing two or more objects. Your opponent will then take the remaining object, and you will win.

3. **Setup of two or more in a single row** – This setup has only one row of objects with at least two objects. This is also an "unsafe" setup and, in order to win, you must simply take all but one object.

USE IN AN INSTRUCTIONAL SETTING (continued)

As you can see, the strategy is somewhat complicated and few students could be expected to discover it on their own. Whether you choose to teach the strategy to your students will depend on the ability level of your students. Teaching the mechanics of the strategy is certainly possible, but most students will find it challenging to implement. If you should decide to present the strategy, here is a table of the binary equivalents for the numbers 1 through 9 (the greatest number of asteroids possible in any row is nine):

Decimal Number	Binary Equivalent
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Preparation

Before using this game with your students, you should first familiarize yourself with the rules and play a few games against Spike, the resident Nim expert. Then examine the range of settings available and, if necessary, modify the settings to meet your needs or the ability level of your students. See pages 3-5 for information on how to change these settings on the disk. Here are a few things to consider while deciding what the appropriate settings might be for your students:

Number of rows (2-5) – A game with two rows is fairly trivial to play. The three-row version is the most common. Games using four or five rows will offer a greater challenge for more advanced players.

Asteroids per row (1-9) – It is probably best not to have the same number of asteroids in any two rows.

Player blasting the last asteroid wins or loses? – Over the centuries, Nim has commonly been played both ways.

Who starts the next game? – Alternating the starters or randomly picking the starter is certainly a fair way to approach this setting. Starting the game, however, is usually the key to winning, once you have discovered the strategy. Therefore, allowing the loser to start a game will provide students who may not yet have discovered the strategy with more of an opportunity to succeed.

USE IN AN INSTRUCTIONAL SETTING (continued)

The game can be played by individual students competitively or by small groups of students working cooperatively against one of the computer opponents. Three opponents are provided: Spike, Ace, and Biff. Spike uses a winning strategy at all times and will win all games started with a winning advantage and any game in which a player makes an error in reasoning. Ace starts each game in a somewhat random fashion, but eventually starts using sound strategy. Biff plays in a very haphazard fashion and is easy to defeat. You may want to suggest to your students that they start playing against Biff, then try Ace, and finally try Spike. The game can also be played competitively between two students.

Before using **Space Nim**, you may want to consider introducing students to the game, using actual objects, such as small pieces of paper or checkers. Pair up students, give them a set of objects, and explain the rules. Do not use the same number of objects as you plan to use in **Space Nim**. Also, let the students decide on their own who should start each game. After a while, many of the students will have discovered a strategy that seems to allow them to win quite often. They should also have discovered that starting the game can sometimes be advantageous. When the students actually play **Space Nim** with different rules, it should be readily apparent whether their strategy was a good one. Often students develop a winning strategy by memorizing a winning combination of moves, but this strategy does not transfer to a new situation. Therefore, encourage students to chart the moves made by both players during a game and to look for patterns.

Minimal time is required to play a single game of **Space Nim**, so you may wish to set up sessions in which students play several rounds and determine a winner by who wins the most rounds. If time permits, a **Space Nim** tournament could be organized.

USE IN AN INSTRUCTIONAL SETTING (continued)

Using the Program

To play **Space Nim**, select it from the main menu (Figure 1). If this is the first time your students are using this package, you may first want to have them read through the Player Profiles to get an indication of the abilities of the three computer players (Figure 2).

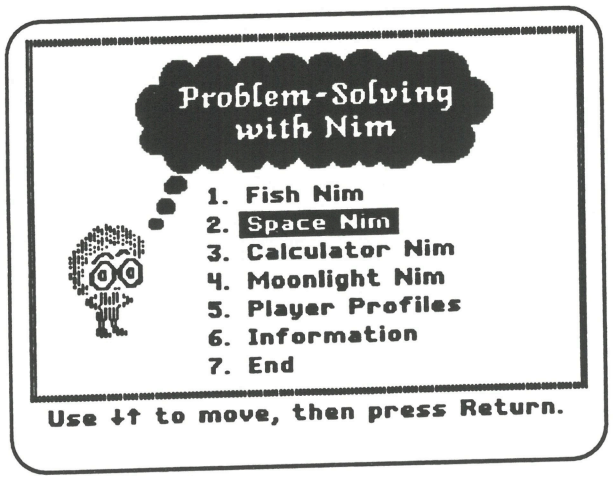


Figure 1

Player Profiles
Biff is a newcomer to the sport of Nim. Even though Biff has not developed too many successful strategies yet, this novice can provide you with hours of practice and fun.
Press Space Bar to continue

Figure 2

The first screen summarizes the rules of the game based on the current settings. If players are allowed to change settings, that option will also be displayed (Figure 3). If players are not allowed to change settings, only a "Press Space Bar to continue" message will be displayed. If a change in settings is selected, the screen shown in Figure 4 is seen and changes can now be made. Student changes are temporary and are not saved on the disk; they will be lost after students exit from the game and return to the main menu.

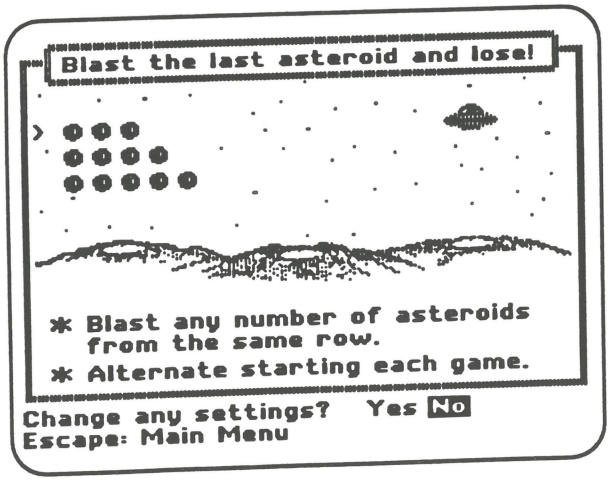

Blast the last asteroid and lose!
* Blast any number of asteroids from the same row.
* Alternate starting each game.
Change any settings? Yes No
Escape: Main Menu

Figure 3

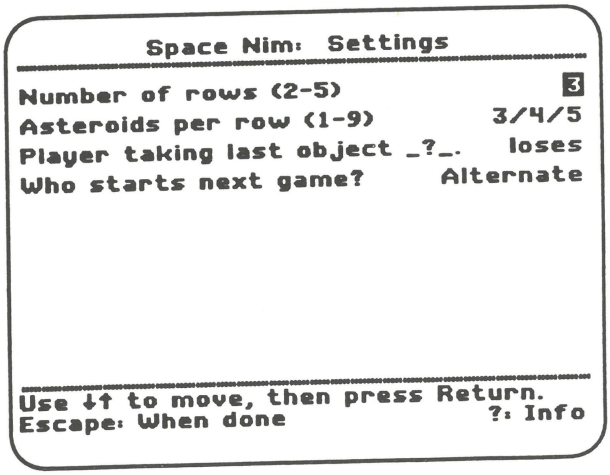

Space Nim: Settings
Number of rows (2-5) 3
Asteroids per row (1-9) 3/4/5
Player taking last object _?_. loses
Who starts next game? Alternate
Use ↓↑ to move, then press Return.
Escape: When done ?: Info

Figure 4

USE IN AN INSTRUCTIONAL SETTING (continued)

Before starting a new game, the first player is asked to enter his or her first name and choose a character to represent him or her during the game (Figure 5). The player is then asked to select an opponent (Figure 6). Descriptions of the style of play for the computer players (Spike, Ace, and Biff) are available by selecting Player Profiles on the main menu.

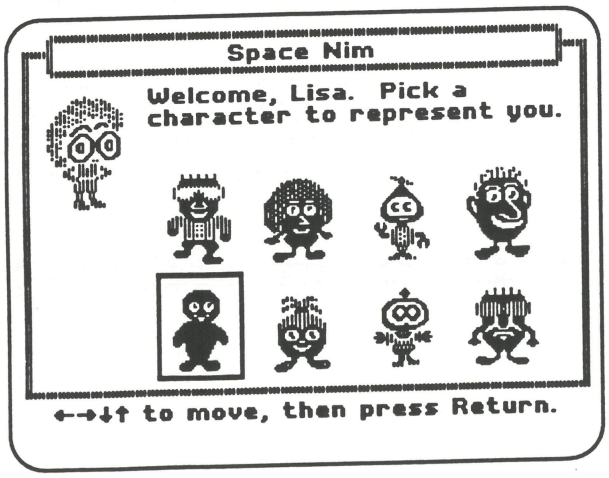


Figure 5

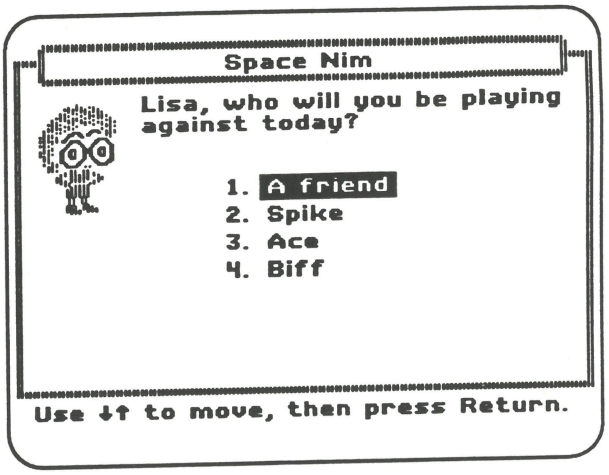


Figure 6

The game hostess, Ima Thinker, will randomly decide who starts the first game (Figure 7). From then on, the player starting each game will be determined according to the game settings. The main game screen will then appear. Instructions for all possible options at this point are shown at the bottom of the screen (Figure 8). Up to one row of asteroids can be taken on a turn by using the arrow keys and the Space Bar. All asteroids blasted on a turn must be taken from the same row. A turn can be ended before taking the entire row by pressing the Return Key. At least one asteroid from any row must be taken on a turn.

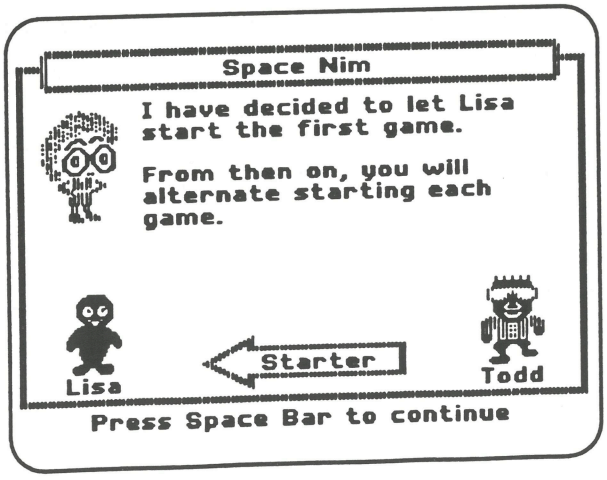

Space Nim
I have decided to let Lisa start the first game.
From then on, you will alternate starting each game.
Lisa
Starter
Todd
Press Space Bar to continue

Figure 7

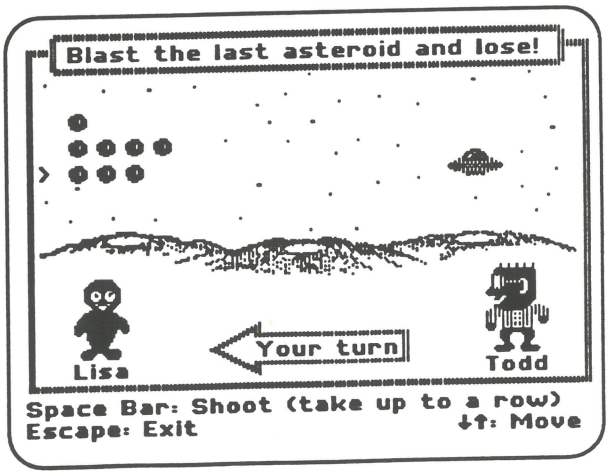


Figure 8

USE IN AN INSTRUCTIONAL SETTING (continued)

After the last asteroid is blasted, the winner is announced (Figure 9). Remember, depending on the game settings, a player could win or lose by blasting the last asteroid. The current setting is reflected in the message printed at the top of the screen. Following each round, a summary screen that gives the current number of wins for each player is shown (Figure 10). At this point, a player can choose to play again, change players or characters, or quit and return to the main menu. If allowed, game settings can also be changed at this point. See page 18 for more information about this option.

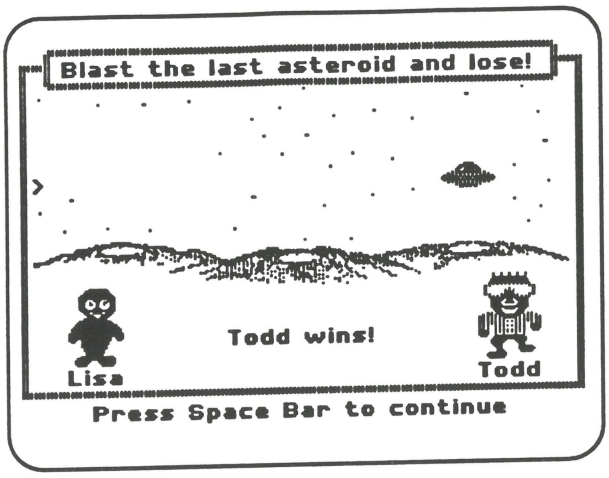


Figure 9

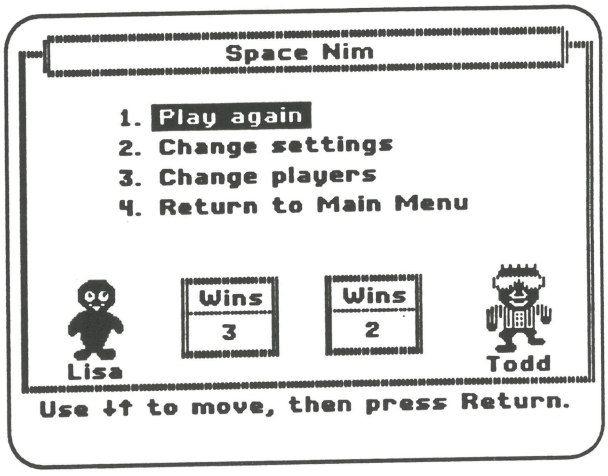
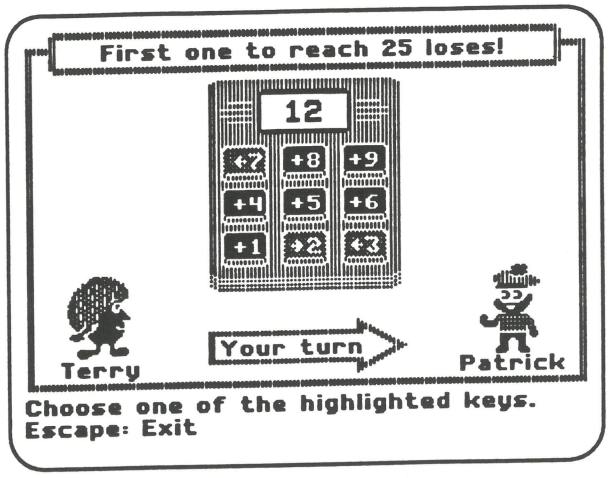


Figure 10

THE PROGRAM AT A GLANCE



Program Type: Problem-solving game

Classroom Use: Individual student (plays against a computer opponent), two students (play against each other), or small group (cooperative learning)

Description: **Calculator Nim** is a rather unique adaptation of an ancient game to a recent invention. The basic game is very similar in nature to **Fish Nim**; some unique games can be designed, however, by regulating the use of certain keys in a variety of ways. The basic game can be played by using either addition or subtraction of single digits (1-9). In the addition game, players start at zero and take turns adding single digits as they try to reach (or avoid) a certain target value. In the subtraction game, players start at some predetermined value and take turns subtracting single digits as they try to reach (or avoid) zero. In other versions of the game, certain keys can be de-activated in various ways.

Objectives:

- to provide students with an engaging problem-solving activity
- to provide an application using addition and subtraction
- to practice using visual reasoning
- to develop problem-solving strategies

USE IN AN INSTRUCTIONAL SETTING

Background Information

Many of the books and articles that have been written about games and tricks that can be done using calculators usually contain a suggestion for some type of Nim game. But playing even a simple game of Nim with a calculator is often far more complicated than it needs to be! For example, if a student played a game in which the players took turns adding single digits until someone reached or exceeded the value of 50, players would need to enter a series of key presses to indicate the number, the math operation, and, in some cases, the Equal-Sign (=) Key. If a mistake were made by pressing a wrong key, the game probably could not be easily resumed. This is the reason more complicated Nim games that use calculators are not widely played or studied within a problem-solving context.

Using the computer-controlled calculator in **Calculator Nim** offers many advantages. Students are quite familiar with calculators and the process of adding or subtracting digits to arrive at some given target value. Only single-key presses are required to perform a complete operation, and rather complicated versions of the game can easily be played without a chance of making a mistake during key selection. Therefore, **Calculator Nim** makes it much more feasible to use the calculator as the basis for an engaging problem-solving activity.

Rules for Calculator Nim

There are six different games that can be played with **Calculator Nim**. Each game is dependent on which keys can be used to play the game. The following rules, however, apply to all the games:

1. Players take turns adding (or subtracting) single digits.
2. Only highlighted keys can be selected.
3. Depending on the current settings, the first player to reach or exceed the target value either wins or loses. (When using subtraction, the target value is 0.)

The six different games based on key selection are:

1. **All keys (1-9) allowed** – This is the basic game in which all keys are always active.

2. **Each key can only be used once** – This game is easier to plan a strategy for since there are a very limited number of choices in key selection and, once used, a key is no longer available.

3. **Only certain keys can be used** – You can customize the game to include only those keys that you want active. At least two keys must be selected and the keys selected are always available to either player.

4. **The next key pressed must be adjacent to the last key pressed** – This game can be rather challenging since you not only pick a key to press, but you also want to limit the choices available to your opponent on his or her next move. In this game, adjacent includes those keys that are diagonally adjacent. The player starting the game has the full set of keys from which to select.

USE IN AN INSTRUCTIONAL SETTING (continued)

5) **The next key pressed must be from a different (horizontal) row than the last key pressed** – Again, this game offers a challenging situation since you not only choose a key, but you also limit your opponent's choices. The player starting the game has the full set of keys from which to select.

6) **The next key pressed must be from a different (vertical) column than the last key pressed** – This version is perhaps slightly more challenging than the game involving horizontal rows since the values of keys in the columns provide a wider range of choices. The player starting the game has the full set of keys from which to select.

Strategy

The strategy for the first type of game in which all the keys (1-9) are allowed is the same strategy as used in **Fish Nim**. See pages 7-9 for a complete discussion of this strategy. Let the target or starting value represent the total (T) and, since up to nine can be selected on any turn, a controlled round would mean a total of ten should be taken on each controlled move. When using addition, the difference between the target value and the current total will be the total (T) value.

The other versions of **Calculator Nim** are more involved and the strategies will be more complex. Since these games are rather new forms of Nim, little is known about general strategies that might work. So, finding strategies to consistently win any of these games is a challenge open to everyone. Have fun and good luck!

Preparation

Before using this game with your students, you should first familiarize yourself with the rules and play a few games against Spike, the resident Nim expert. Then examine the range of settings available and, if necessary, modify the settings to meet your needs or the ability level of your students. See pages 3-5 for information on how to change these settings on the disk. Here are a few things to consider while deciding what the appropriate settings might be for your students:

Operation used – You can choose either addition or subtraction.

Target or starting value (11-44) – Keeping this value small will shorten the game and allow players more of an opportunity to visualize a strategy or check out various moves.

Keys allowed – The basic way to play this game is be to have all the keys active all of the time. This is the only version of the game that will have a generalized strategy that can be quickly applied.

First to reach target wins or loses? – Over the centuries, Nim has commonly been played both ways.

Who starts the next game? – Alternating starters or randomly picking the starter is certainly a fair way to approach this setting. Starting the game, however, is often the key to winning once you have discovered the strategy. Therefore, allowing the loser to start a game will provide students who may not yet have discovered the strategy more of an opportunity to succeed.

USE IN AN INSTRUCTIONAL SETTING (continued)

The game can be played by individual students competitively or by small groups of students working cooperatively against one of the computer opponents. Three opponents are provided: Spike, Ace, and Biff. Spike uses a winning strategy when all keys are active and will win any games started with a possible winning advantage. Spike will also win any game in which a player makes an error in reasoning. Ace starts each game in a somewhat random fashion but eventually starts using some strategy. Biff plays in a very haphazard fashion and is easy to defeat. You may want to suggest to your students that they start playing against Biff, then try Ace, and finally try Spike. The game can also be played competitively between two students.

Before using **Calculator Nim**, you may want to consider introducing students to the game using calculators. Pair up students, give them a calculator, and explain the rules. Do not use the same target value or starting value that you plan to use in the **Calculator Nim** game and stay with the basic game in which they can use any key on their turn. Also, let them decide on their own who should start each game. After a while, many of the students will have discovered a strategy that seems to allow them to win quite often. They should also have discovered that starting the game is often advantageous. When the students actually play **Calculator Nim** with different rules, it should be readily apparent whether their strategy was a good one. Often students develop a winning strategy by memorizing a winning combination of moves, but this strategy does not transfer to a new situation. Therefore, encourage students to chart the moves made by both players during a game and look for patterns.

Minimal time is required to play a single game of **Calculator Nim**, so you may wish to set up sessions in which students play several rounds and determine a winner by who wins the most rounds. If time permits, a **Calculator Nim** tournament could be organized.

USE IN AN INSTRUCTIONAL SETTING (continued)

Using the Program

To play **Calculator Nim**, select it from the main menu (Figure 1). If this is the first time your students have used this package, you may first want to have them read through the Player Profiles to get an indication of the abilities of each of the three computer players (Figure 2).

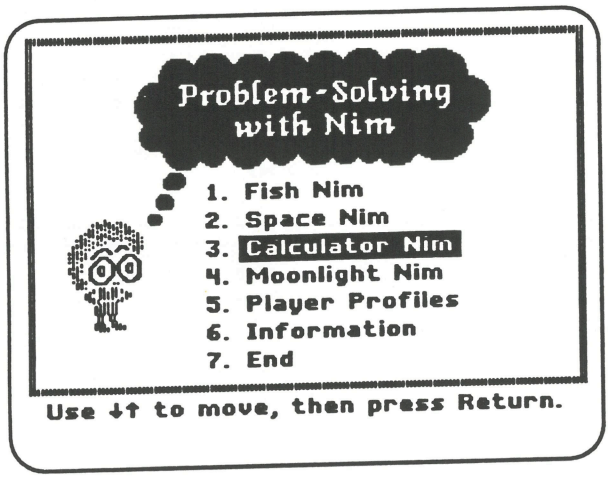


Figure 1

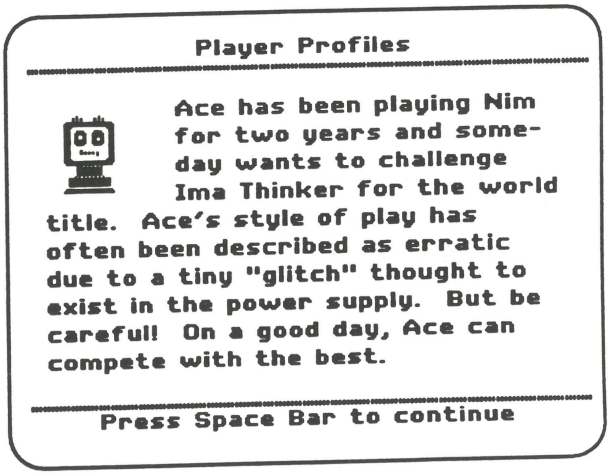

Player Profiles
Ace has been playing Nim for two years and someday wants to challenge Ima Thinker for the world title. Ace's style of play has often been described as erratic due to a tiny "glitch" thought to exist in the power supply. But be careful! On a good day, Ace can compete with the best.
Press Space Bar to continue

Figure 2

The first screen summarizes the rules of the game based on the current settings. If players are allowed to change settings, that option will also be displayed (Figure 3). If players are not allowed to change settings, only a "Press Space Bar to continue" message will be displayed. If a change in settings is selected, the screen shown in Figure 4 is seen and changes can now be made. Student changes are temporary and are not saved on the disk; they will be lost after students exit from the game and return to the main menu.

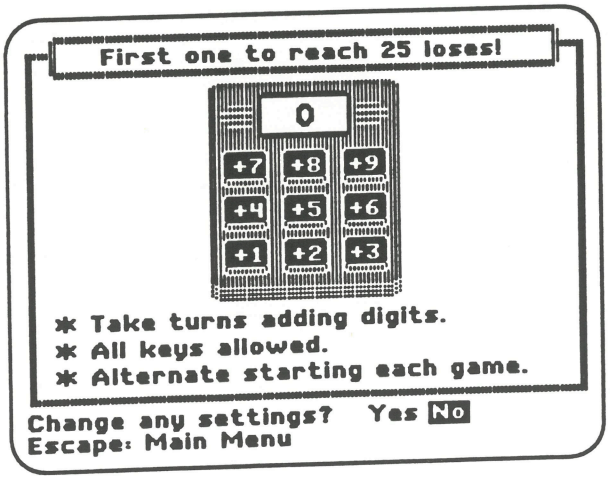


Figure 3

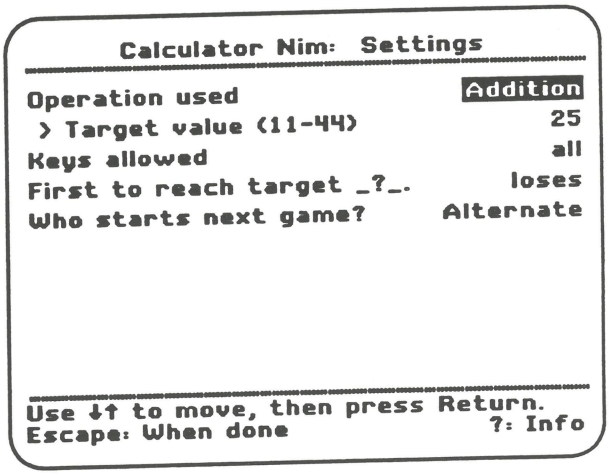

Calculator Nim: Settings
Operation used Addition
> Target value (11-44) 25
Keys allowed all
First to reach target _?_. loses
Who starts next game? Alternate
Use ↓↑ to move, then press Return.
Escape: When done ?: Info

Figure 4

USE IN AN INSTRUCTIONAL SETTING (continued)

Before starting a new game, the first player is asked to enter his or her first name and choose a character to represent him or her during the game (Figure 5). The player is then asked to select an opponent (Figure 6). Descriptions of the style of play for the computer players (Spike, Ace, and Biff) are available by selecting Player Profiles on the main menu.

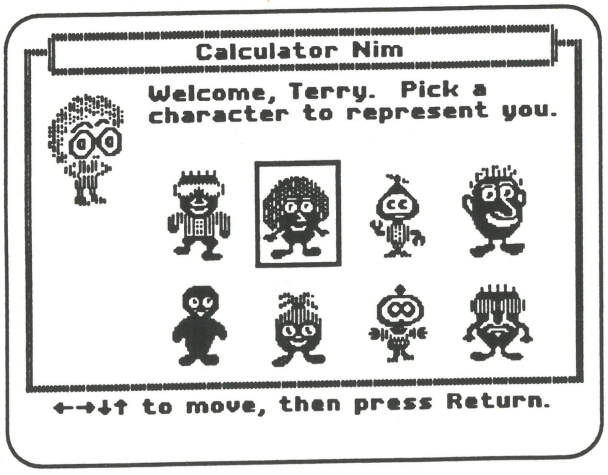


Figure 5

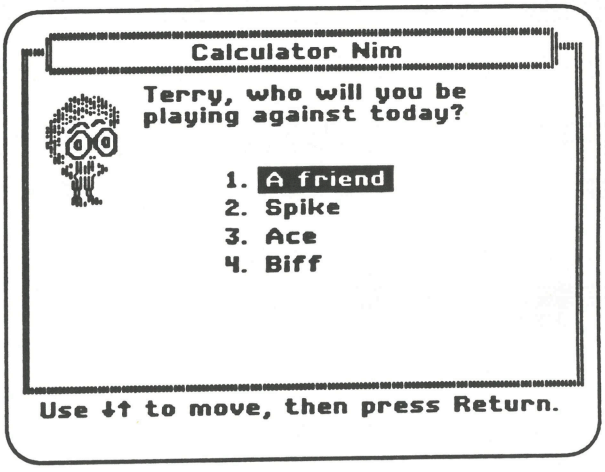


Figure 6

The game hostess, Ima Thinker, will randomly decide who starts the first game (Figure 7). From then on, the player starting each game will be determined according to the game settings. The main game screen will then appear. Instructions for all possible options at this point are shown at the bottom of the screen (Figure 8). Any one of the highlighted keys shown can be selected on a turn by pressing the corresponding numerical key.

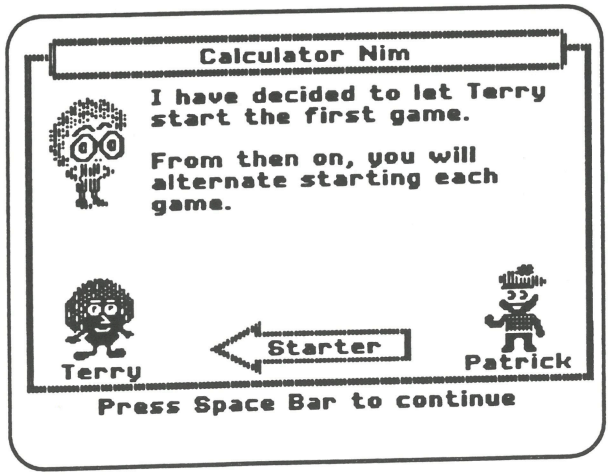

Calculator Nim
I have decided to let Terry start the first game.
From then on, you will alternate starting each game.
Terry
Starter
Patrick
Press Space Bar to continue

Figure 7

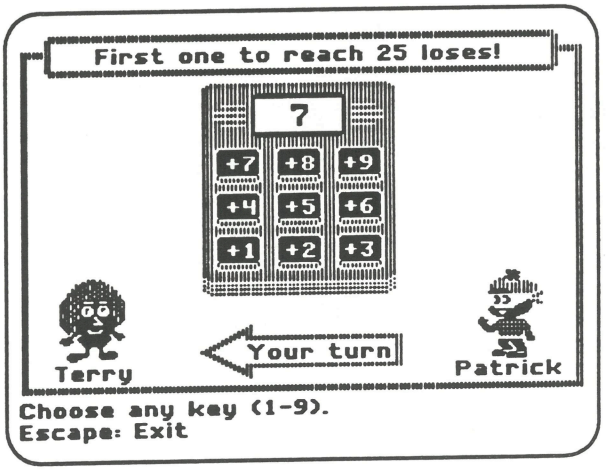


Figure 8

USE IN AN INSTRUCTIONAL SETTING (continued)

After the target value is reached, the winner is announced (Figure 9). Remember, depending on the game settings, a player could win or lose for being the first player to reach the target value. The current setting is reflected in the message printed at the top of the screen. Following each round, a summary screen that gives the current number of wins for each player is shown (Figure 10). At this point, a player can choose to play again, change players or characters, or quit and return to the main menu. If allowed, game settings can also be changed at this point. See page 25 for more information about this option.

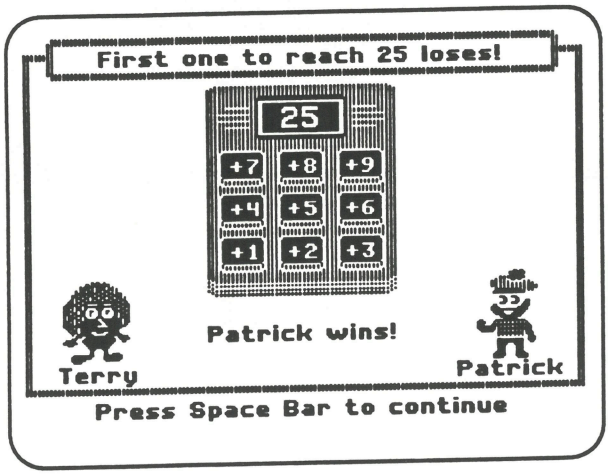


Figure 9

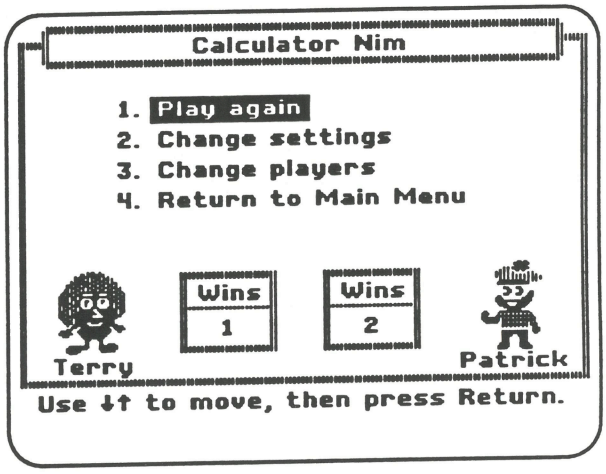


Figure 10

THE PROGRAM AT A GLANCE

Program Type: Problem-solving game

Classroom Use: Individual student (plays against a computer opponent), two students (play against each other), or small group (cooperative learning)

Description: **Moonlight Nim** is a very challenging version of Nim. In fact, there is no known strategy that can ensure a win. The game is played on a rectangular grid containing lights that must be switched off. Players take turns switching off up to a given number of adjacent lights on their turn. Depending on the settings, the player turning off the last light either wins or loses.

Objectives:

- to provide students with an engaging problem-solving activity
- to provide an application using a two-dimensional game board
- to practice using visual reasoning
- to develop problem-solving strategies

USE IN AN INSTRUCTIONAL SETTING

Background Information

Many versions of Nim have been devised recently with a rectangular arrangement of counters that are removed in some specified fashion. Among some of the more popular versions are *Tac Tix* and *Extended Nimbi*.

Tac Tix was developed in Denmark by Pat Hein. It uses a square arrangement of counters (3x3 and 4x4 are most commonly used), which players take turns removing. Players can remove any number of adjacent counters from any horizontal row or vertical column. To date, some heuristic solutions have been documented for the 3x3 game; however, the 4x4 game still provides problem-solvers with many challenges!

Extended Nimbi is played with counters on any rectangular grid. In this version, each player has an assigned direction, either horizontal or vertical, in which they must make all their moves. Players make moves by selecting any counter on the grid and then must take all adjacent counters in the row, either horizontally or vertically, according to their assigned direction. These conditions result in a game that does have a general solution.

Rules for Moonlight Nim

1. The game is played on a rectangular grid with up to four rows and eight columns of lights.
2. Players take turns switching off up to a specified number of adjacent lights (from two to five, according to the current settings). An adjacent light is defined as any light to the left, the right, above, or below the selected light.
3. Each player must switch off at least one light per turn.
4. The player turning off the last light loses (or wins, if set this way).

Strategy

A general strategy for this particular Nim game has not yet been developed; as the remaining lights become separated into smaller groups, however, some of the basic principles used in **Space Nim** can be incorporated.

USE IN AN INSTRUCTIONAL SETTING (continued)

Preparation

Before using this game with your students, you should first familiarize yourself with the rules and play a few games against Spike, the resident Nim expert. Then examine the range of settings available and, if necessary, modify the settings to meet your needs or the ability level of your students. See pages 3-5 for information on how to change these settings on the disk. Here are a few things to consider while deciding what the appropriate settings might be for your students:

Rows of lights (1-4) – By keeping the size of the rectangular grid small, players will be able to spend more time visualizing a strategy and exploring alternatives. The one-row version may seem trivial, but it can offer some interesting challenges in planning a strategy.

Columns of lights (2-8) – Again, keeping the overall size small will tend to promote more strategy.

Maximum number of lights per turn (2-5) – Allowing more lights per turn will shorten the game time.

Player taking the last light wins or loses? – Over the centuries, Nim has commonly been played both ways.

Who starts the next game? – Alternating starters or randomly picking the starter is certainly a fair way to approach this setting.

The game can be played by individual students competitively or by small groups of students working cooperatively against one of the computer opponents. Three opponents are provided: Spike, Ace, and Biff. While Spike and Ace do have some techniques that they employ, they have no strategy that will ensure them of winning consistently. Biff plays in a very haphazard fashion and is easy to defeat. You may want to suggest to your students that they start playing against Biff, then try Ace, and finally try Spike. The game can also be played competitively between two students.

Before using **Moonlight Nim**, you may want to consider introducing students to the game using paper and pencil. Pair up students, give them some grid paper, and explain the rules. Use a different set of rules than the ones you plan on using with the computer version. Let them decide on their own who should start each game. After a while, many of the students will have discovered a strategy that seems to allow them to win quite often. When the students actually play **Moonlight Nim** with different rules, it should be readily apparent whether their strategy was a good one. Often students develop a winning strategy by memorizing a winning combination of moves, but this strategy does not transfer to a new situation. Therefore, encourage students to chart the moves made by both players during a game and to look for patterns.

Minimal time is required to play a single game of **Moonlight Nim**, so you may wish to set up sessions in which students play several rounds and determine a winner by who wins the most rounds. If time permits, a **Moonlight Nim** tournament could be organized.

USE IN AN INSTRUCTIONAL SETTING (continued)

Using the Program

To play **Moonlight Nim**, select it from the main menu (Figure 1). If this is the first time your students have used this package, you may first want to have them read through the Player Profiles to get an indication of the abilities of each of the three computer players (Figure 2).

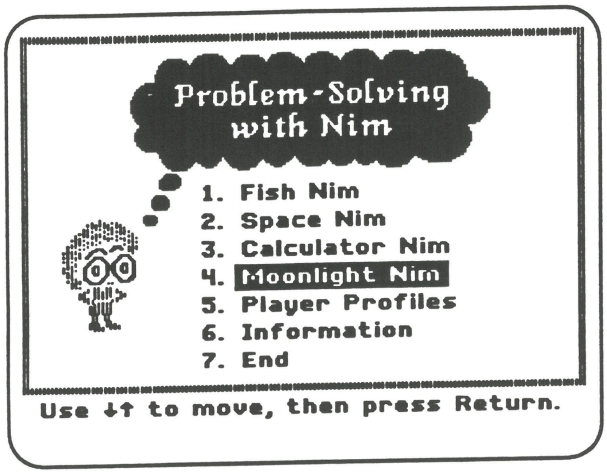


Figure 1

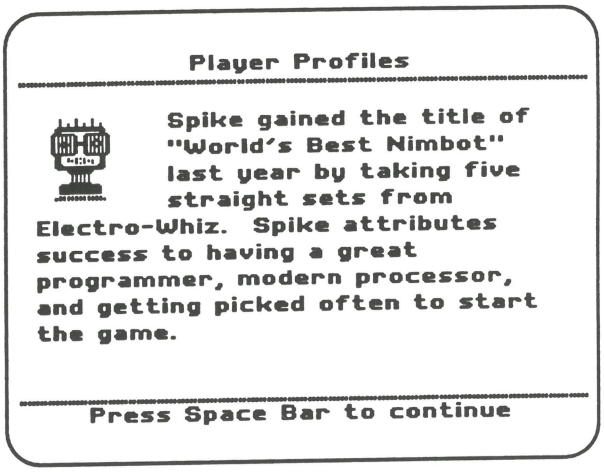

Player Profiles
Spike gained the title of "World's Best Nimbot" last year by taking five straight sets from Electro-Whiz. Spike attributes success to having a great programmer, modern processor, and getting picked often to start the game.
Press Space Bar to continue

Figure 2

The first screen summarizes the rules of the game based on the current settings. If players are allowed to change settings, that option will also be displayed (Figure 3). If players are not allowed to change settings, only a "Press Space Bar to continue" message will be displayed. If a change in settings is selected, the screen shown in Figure 4 is seen and changes can now be made. Student changes are temporary and are not saved on the disk. They will be lost after students exit from the game and return to the main menu.

Turn off the last light and lose!
* Turn off up to 4 adjacent lights.
* Alternate starting each game.
Change any settings? Yes No
Escape: Main Menu

Figure 3

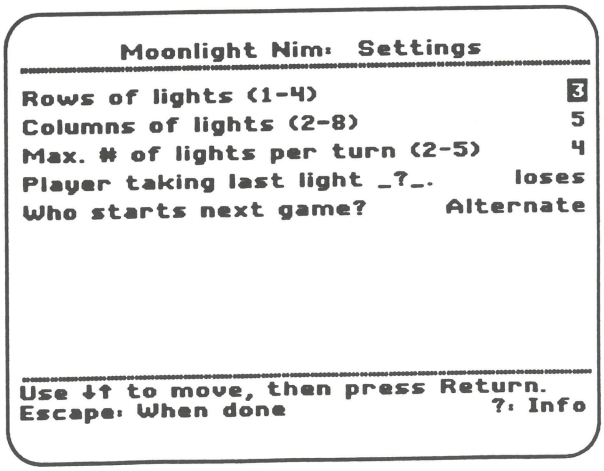

Moonlight Nim: Settings
Rows of lights (1-4) 3
Columns of lights (2-8) 5
Max. # of lights per turn (2-5) 4
Player taking last light _?_. loses
Who starts next game? Alternate
Use ↓↑ to move, then press Return.
Escape: When done ?: Info

Figure 4

USE IN AN INSTRUCTIONAL SETTING (continued)

Before starting a new game, the first player is asked to enter his or her first name and choose a character to represent him or her during the game (Figure 5). The player is then asked to select an opponent (Figure 6). Descriptions of the style of play for the computer players (Spike, Ace, and Biff) are available by selecting Player Profiles on the main menu.

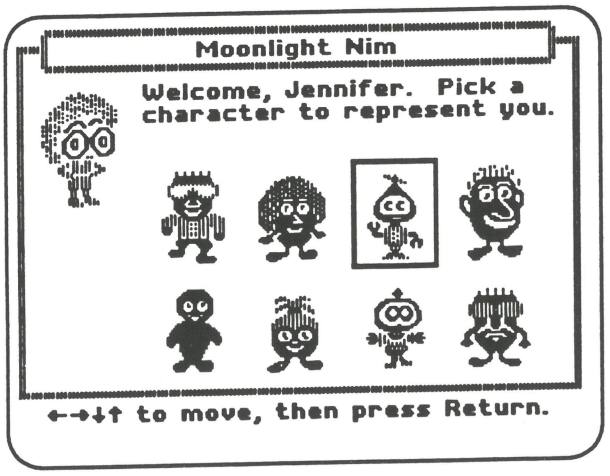


Figure 5

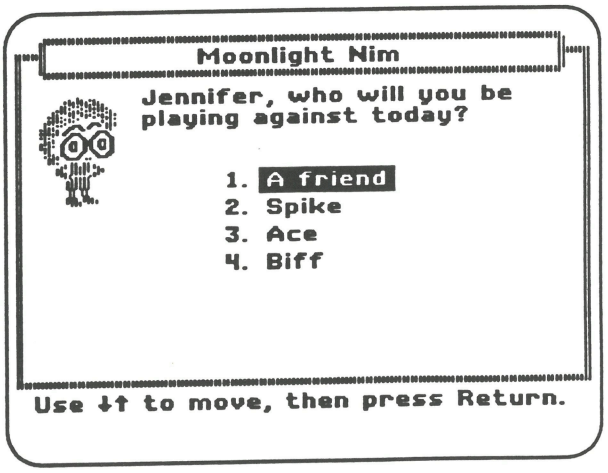


Figure 6

The game hostess, Ima Thinker, will randomly decide who starts the first game (Figure 7). From then on, the player starting each game will be determined according to the game settings. The main game screen will then appear. Instructions for all possible options at any point are shown at the bottom of the screen (Figure 8). Up to the specified number of lights can be turned off on each turn by using the arrow keys and the Space Bar. To end a turn before turning off the maximum number of lights allowed, press the Return Key. At least one light must be switched off per turn.

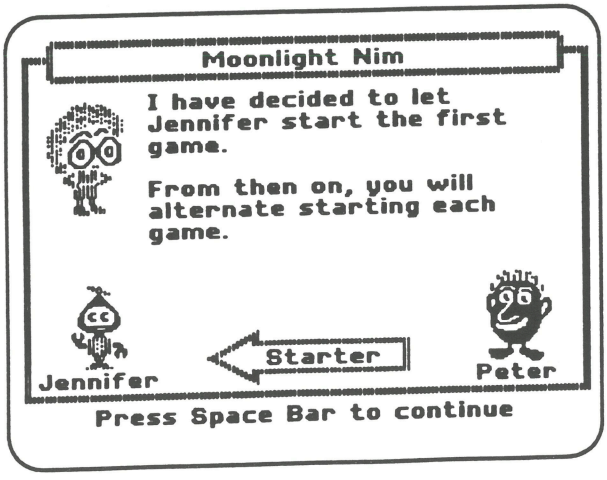

Moonlight Nim
I have decided to let Jennifer start the first game.
From then on, you will alternate starting each game.
Jennifer
Starter
Peter
Press Space Bar to continue

Figure 7

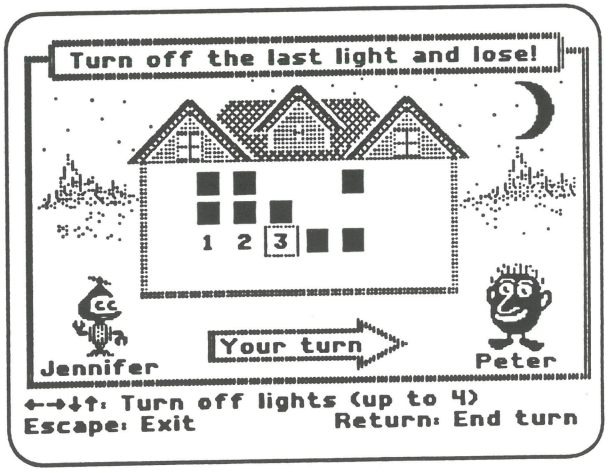


Figure 8

USE IN AN INSTRUCTIONAL SETTING (continued)

After the last light is switched off, the winner is announced (Figure 9). Remember, depending on the game settings, a player could win or lose by switching off the last light. The current setting is reflected in the message printed at the top of the screen. Following each round, a summary screen that gives the current number of wins for each player is shown (Figure 10). At this point, a player can choose to play again, change players or characters, or quit and return to the main menu. If allowed, game settings can also be changed at this point. See page 32 for more information about this option.

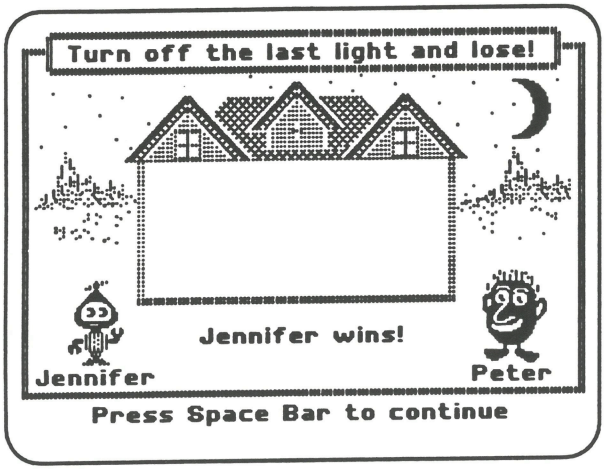


Figure 9

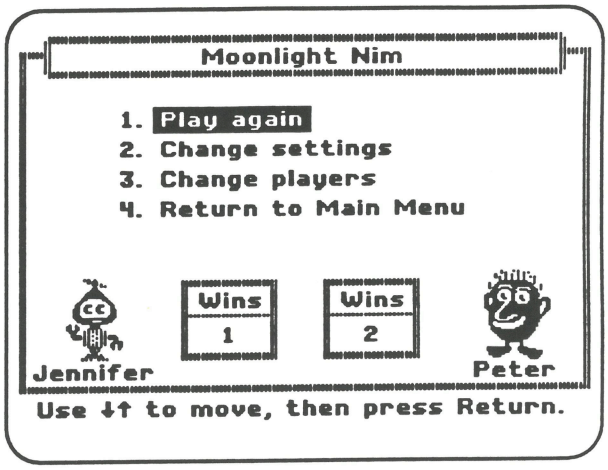


Figure 10

THINKING SKILLS

Thinking Skills and *Problem-Solving with Nim*

Teachers are faced with the tremendous task of preparing today's students for tomorrow's world—a world characterized by change in an information-rich environment. Thinking skills are at the heart of this thriving, changing environment, for these are the behaviors students must practice in school and continue to apply for the rest of their lives.

It wasn't long ago that thinking skills were considered exclusive to gifted and enrichment classes. Today, however, thinking skills are viewed as an essential component of the total school curriculum. Developing these skills is the goal of each individual discipline. Many educators have, in fact, come to view thinking skills as perhaps the most basic of the basic skills because they facilitate the acquisition of all other learning.

At MECC, we view computer software as a vehicle for fostering students' thinking. Our products are curriculum-based, with thinking skills as a thread within subject areas. This provides an environment with many opportunities for teachers to highlight and reinforce thinking skills.

We believe teachers play a critical role in determining the classroom environment for thinking. Naturally, many teachers have taught thinking skills and will continue to do so using a variety of strategies. Our commitment is to provide teachers with the materials that help them do their job well: high-quality software that promotes the application of thinking skills.

Our approach to thinking skills reflects what both research and effective classroom practice has shown. That is, the approach that is most effective and appeals to most teachers is one that infuses thinking skills into existing content areas. Educators have told us they are interested in thinking skills as a method used in the instruction of a topic, not as a subject. By infusing thinking skills into existing content areas, MECC products integrate easily into teachers' curricula while providing a rich environment for students to practice skillful thinking. We strive to meet the challenge teachers face in promoting the skills that students need.

If schools are to integrate the teaching of thinking with regular academic instruction, they need to know which aspects of thinking to teach. After exploring the research that has been done in the area of thinking skills, MECC has chosen as a base the *Dimensions of Thinking* framework, published in 1988 by the Association of Supervision and Curriculum Development (ASCD). We chose this framework because it pulls together research and models from a variety of sources and brings the theory to the classroom level, applying it to that environment. In addition to knowing the subject matter that is covered, teachers now can see the specific thinking skills that are challenged within a product.

This section highlights ways in which teachers can use ***Problem-Solving with Nim*** to promote thinking skills with their students. The following pages provide examples of how ***Problem-Solving with Nim*** relates to the ASCD core thinking skills framework. Although only one thinking skill per category is correlated to a specific part of the product, each skill can be practiced on many levels and in many aspects of the product.

We realize the importance of thinking skills in the curriculum. We believe it is essential that students be taught thinking skills so that they have the tools to understand the past, deal with the present, and prepare for the future. We are confident that you will find ***Problem-Solving with Nim*** of considerable value in your classroom as you foster student thinking.

A Framework for Thinking

The components used in thinking are referred to as *core thinking skills*. This framework defines those skills that appear in the repertoire of the model learner. Each skill selected is documented in research as important to learning or thinking, is teachable, and is valued by educators as important for students to learn.

The core skills of the ASCD framework are listed and defined below with examples of applications within ***Problem-Solving with Nim***. The skills are neither discrete nor hierarchical. In fact, individual skills draw on other skills and can be used repeatedly in the thinking process. The selected examples are not exhaustive but highlight ways in which these thinking skills are used in ***Problem-Solving with Nim***.

Source: *Dimensions of Thinking*, Association for Supervision and Curriculum Development (ASCD), 1988.

Definition of Core Thinking Skills Categories	Core Thinking Skills Components	*Problem-Solving with Nim* Application
Focusing Skills allow students to attend to selected pieces of information and ignore others. Focusing occurs when students sense a problem, an issue, or a lack of meaning.	**Focusing Skills** • Defining Problems • Setting Goals	Students can change any of several game settings as they try to develop a winning strategy. By changing one setting at a time, students can focus on the effects of changing that variable.
Information-Gathering Skills involve obtaining information and clarifying issues and meanings through inquiry.	**Information-Gathering Skills** • Observing • Formulating Questions	As each game is played, students observe the various key situations that lead to winning. Students begin to inquire about ways to gain an advantage when playing.
Remembering Skills are those activities or strategies that students consciously engage in to store and retrieve information from long-term memory. Activating prior knowledge falls under this category.	**Remembering Skills** • Encoding • Recalling	As each game is played, students will be able to observe winning strategies. Students will be able to draw on this knowledge as they play future games.

THINKING SKILLS (continued)

Definition of Core Thinking Skills Categories	Core Thinking Skills Components	*Problem-Solving with Nim* Application
Organizing Skills are used to arrange information so that it can be understood or presented more effectively.	**Organizing Skills** • Comparing • Classifying • Ordering • Representing	Students can construct tables and charts representing the moves taken in various games.
Analyzing Skills are used to clarify existing information by examining parts and relationships. Through analysis, students identify and distinguish components, attributes, claims, assumptions, or reasoning.	**Analyzing Skills** • Identifying Attributes and Components • Identifying Relationships and Patterns • Identifying Main Ideas • Identifying Errors	Students can look for patterns and relationships in the set of moves used during a game and analyze them as they try to develop winning strategies.
Generating Skills involve using the students' prior knowledge to add information beyond what is given. Connections between new ideas and prior knowledge are made as new information and ideas are recast into new structures.	**Generating Skills** • Inferring • Predicting • Elaborating	Once students have developed what is thought to be a good strategy, some of the game settings can be changed in order to test their approach.
Integrating Skills involve putting together the relevant parts or aspects of a solution, understanding, principle, or composition and incorporating this integrated information into a new understanding.	**Integrating Skills** • Summarizing • Restructuring	Many of the strategies used in winning one version of Nim can often be incorporated into a strategy for another version. For example, the strategy used in **Fish Nim** can be used in **Calculator Nim.**
Evaluating Skills involve assessing the reasonableness and quality of ideas.	**Evaluating Skills** • Establishing Criteria • Verifying	At this point, students can share the process and strategies they employed while playing the various Nim games.

COOPERATIVE LEARNING

A Cooperative-Learning Activity

Although ***Problem-Solving with Nim*** is based on a competitive model, structuring an activity that involves cooperative groups provides students with excellent opportunities to work together through the problem-solving process.

Working in cooperative groups, students take an active role in analyzing a game, suggesting and testing alternative strategies to win, and discussing their effectiveness. Through group discussions, students help each other clarify their thinking about the requirements of the game and become more aware of their own approach to problem-solving. Because each student in a group models different strategies as he or she plays the game, everybody's repertoire of problem-solving strategies is enriched and expanded.

The activity described below involves students in cooperative-learning groups at the computer. It provides general guidelines for structuring the interaction of students, determining the size of the groups, and assigning roles to students.

This activity has been designed with the following cooperative-learning principles in mind:

- The group must work as a team to complete a common task and achieve a common goal.
- Each member has a designated responsibility that he or she must carry out to help the team meet its common goal.
- Team members support each other by offering explanations, asking questions, providing feedback, sharing information, and encouraging each other to learn and participate in the discussions.
- Teams are made up of students with varying ability levels, ethnic and social background, gender, etc.
- The team must regularly evaluate how well they are functioning as a team.

Familiarity with these principles and the techniques that support them will enhance the effectiveness of this lesson. For a thorough discussion of cooperative-learning principles, consult the works of David and Roger Johnson, Spencer Kagan, and Robert Slavin.

Preparation

Time Required:	Approximately two class periods per game
Group Size:	Three students per group (to enhance the quality of the discussions and learning that takes place in the cooperative groups, form groups that are heterogeneous in ability levels and other personal characteristics).
Equipment:	One computer for each group
Materials:	Tasks of Team Members handout (page 42)

COOPERATIVE LEARNING (continued)

Procedure

1. Provide a brief overview of the specific game students are to play.

2. Point out to students that they have three main goals for doing this activity:

    - to devise strategies that will help them win the game;
    - to ensure that each team member understands how to play the game effectively; and
    - to learn to win or lose graciously.

3. Explain to students that in the first period they will form cooperative groups and play against Spike, the best of the computer players. While working cooperatively, they will have the opportunity to share different strategies and discuss how well they work and the conditions under which they are effective.

4. Assign students to their respective groups. Distribute the handout "Tasks of Team Members" to each student. Take a few minutes to discuss the nature of each role and give examples of behaviors that students may exhibit in that role. Students can choose the role they want to play but, after each round of the game, they should rotate roles, ensuring that everyone has a turn at each role.

    Keyboarder:

    - operates the keyboard;
    - seeks group consensus whenever decisions need to be made; and
    - summarizes ideas expressed by the group regarding the effectiveness of the strategy being used.

    Recorder:

    - charts the team moves and the moves made by Spike; and
    - asks group members to explain the reasons for using/ rejecting a particular strategy.

    Encourager:

    - observes the behavior of Spike (for example, what type of opening move does Spike normally make? does it make a difference whether Spike starts the game or not?);
    - encourages each member of the team to talk and to contribute their ideas; and
    - praises group members for contributing ideas or explaining something to the group.

COOPERATIVE LEARNING (continued)

5. Tell students that you will go around observing how well they are working in their groups. You will pay special attention to how everyone is explaining why they think a strategy is effective or ineffective.

6. At the end of the period, provide about ten minutes for students to discuss how well they worked together. Some ideas they may want to think about include naming two things they did well as a group and one thing they need to do better next time. You may also provide feedback on how you saw them work.

7. During the second period, have students compete against students from other teams. While they are competing, do not allow them to receive help from their teammates.

   To keep the competition relatively fair, have students of similar ability levels compete against each other. At the end of the contest, have them get together in their original teams and add up their individual scores to obtain a team score. The team with the most points wins.

Tasks of Team Members

Keyboarder

- operates the keyboard;
- seeks group consensus whenever decisions need to be made; and
- summarizes ideas expressed by the group regarding the effectiveness of the strategy being used.

Recorder

- charts the team's moves and Spike's moves; and
- asks group members to explain the reasons for using/rejecting a particular strategy.

Encourager

- observes the behavior of Spike (for example, what is Spike's usual opening move? does it make a difference whether Spike starts the game or not?);
- encourages each member of the team to talk and contribute their ideas; and
- praises group members for contributing ideas or explaining something to the group.

CREDITS

Problem-Solving with Nim was produced by a MECC development team that included Charolyn Kapplinger, Dick Sisco, Craig Solomonson, and Elizabeth Wendland.

MECC wishes to extend special thanks to the following teachers and their students for their assistance in the development and classroom testing of this package:

Joyce Robinson and Larry Gannon
Island Lake Elementary School
Shoreview, Minnesota

TO THE READER:

MECC has made every effort to ensure the instructional and technical quality of this courseware package. Your comments—as user or reviewer—are valued and will be considered for inclusion in any future version of the product. Please address comments to:

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Q. Is it okay for schools to copy software?

A. No, without the publisher's permission, it's not okay for schools to copy software. Software is protected by copyright law, which says that you can't make copies without the permission of the copyright holder. Copyright law is written this way to protect software programmers and publishers and the investment they've made in their products. The creative teams that develop the software — programmers, writers, graphic artists, content specialists, and others — all deserve fair compensation. Without the protection given by our copyright laws, they would be unable to produce the educational, entertainment and productivity software that adds so much to our daily lives.

Q. *What exactly does the law say about copying software?*

A. The law says that it is illegal to make or distribute copies of copyrighted material, including software, without authorization. If you do so, this is piracy, and you may face not only a civil suit, but also fines of up to $100,000 and jail terms of up to 5 years.

Q. *So I'm never allowed to copy software for any reason?*

A. If a backup copy was not included in the box with your original disk(s), you are permitted to make one copy in order to have both a working copy and a backup copy of the program. Copyright law prohibits you from making additional copies of the software for any other reason without the permission of the software company. If the publisher has authorized any exceptions to the copyright law, they will be stated in the license agreements that accompany all software products.

Q. *But aren't schools allowed to make copies for educational purposes?*

A. No. Like individuals and corporations, educational institutions are bound by the copyright law. Because of their unique position of influence, schools have a particular obligation to abide by the copyright law and educate students about their own responsibilities when using software. Just as it would be wrong to buy one textbook and photocopy it for use by many students, it is wrong for a school to duplicate software without the authorization of the publisher. This means that educators cannot make unauthorized copies for their students, either to use in school or to take home.

Q. *At our school, we share programs all the time. We assume this must be okay, since the school purchased the software in the first place.*

A. Many educators are not aware of how the copyright law applies to them. Without the publisher's authorization to make copies, your school needs to purchase as many copies of a program as you will use. However, many software firms do offer special sales arrangements to schools. These include reduced priced lab packs (a number of programs sold together) and site licenses (arrangements which permit schools to copy for a specific location at a fixed price). **Because these arrangements vary from publisher to publisher, it is essential that you read and understand the license agreement for each program before making any copies.**

Q. *We're planning to install a network for our students. How do we know how many copies of software we'll need to purchase?*

A. Remember that the installation of a network does not change your obligations with regard to the copyright law. When purchasing software for a network, be sure to ask the publisher what types of licensing arrangements are available for networks. Some software publishers allow schools to purchase a network license that authorizes the school to install stand-alone software on a network. In addition, many software publishers create special network versions that license the program to be run on the file server of a network. Because some publishers limit the number of workstations that are permitted to legally access the software on the network, it is very important to check the license agreement for any restrictions that may apply.

Q. *I've read the license agreement for one of the software packages purchased by our school. What if I'm not sure that I understand the arrangement correctly?*

A. If you have trouble understanding the license agreement, help is available. Your school district's media or computer specialist may be able to answer your questions. In addition, you can always contact the software publisher and ask for a clarification of the license agreement as it applies to your school. Finally, if you still have questions, contact the Software Publishers Association for more information about software and the copyright law.

Q. *I'll bet most of the people who copy software don't even know they're breaking the law.*

A. Because the software industry is relatively new and because copying software is so easy, many people are either unaware of the laws governing software use or choose to ignore them. It is the responsibility of each and every software user to read and understand the license agreements of the products they use and to be sure that their software use complies with copyright law. See what you can do to initiate a software use policy statement in your school that everyone respects. Finally, as an educator, help set an example for your students that responsible computer users should be "software legal."

If you have any questions about how the copyright law applies to you and your school, please contact the **Software Publishers Association at 202-452-1600.**

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